POWER PLANT ENGINEERING

Established Over 29 Years

VOL. XXIX CHICAGO, MARCH 1, 1925 No. 5

269

Contents of this Issue

Page

South Bend's New Pumping Station. Illustrated.....270

Evaporative Tests at River Rouge. Illustrated.....275

Application of Powdered Coal to Boilers. By Henry Kreisinger. Illustrated.....279

Multiple Exhaust Blading in Steam Turbines. By P. C. Eppelsheimer. Illustrated.....282

Boiler and Turbine Room Instruments......283

Economic Operation of the Power Plant. By John D. Morgan Illustrated.....285

Operation of Converting Apparatus VII. By V. E. Johnson Illustrated.....288

Insulating Oils for Circuit Breakers. By Dean Harvey. Illustrated.....291

Side Lights on Power Plant Lighting. By H. Carroll....293

Practical Applications of Hydraulic Principles, II. By R. T. Livingston. Illustrated.....294

Heating and Ventilating a Steam Power Station. By D. S. Boyden and A. B. Williams.....296

Treating Basement Walls to Prevent Seepage.....298

Careful Operation of Reboiling System Gives Good Ice. By W. H. Howze.....299

Letters Direct from the Plant: Recovering Broken Plunger of Deep-Well Pump. Reinforced Concrete Designed from Tables. Proper Care of Gage Glasses Prevents Trouble. Emergency Water Heater Uses Steam Jets. Force-Feed Lubricator Has Advantages over Hydrostatic Type. Pipe Vibration Caused Noise and Necessitated Furnace Repair. How Is an Engineer's Success Measured? Illustrated....300

Questions and Answers: Why Riding Cutoff Engine Pounds. Calculating Transformer Sizes and Short Transmission Lines. Sooty Tubes May Cause Low Boiler Capacity. Underground Pipe Expansion Taken by Bends. Illustrated 303

Condensate from the World's Power Plant. By William Sibley.....306

Editorial Comment: Heating and Ventilation of Power Stations. Practical Application of Exact Data. Steam Table Research Workers Report Progress. Checking Up on the Cause of Waste. Three-Fold Responsibility of the Fireman.....308

Diesel Engine Automatically Lubricated. Illustrated.....310

Device Trues Commutator in Place on Motor. Illustrated.312

Automatic Cellar Drainer Operates on Water Pressure. Illustrated.....313

Water Column Illuminator. Illustrated.....313

Overhead Line Materials.....313

Heater Responds Quickly to Hot Water Demand. Illustrated.314

Hydraulic Balance Obtained in Double Suction Pump. Illustrated.....314

New Test Code for Steam Boilers.....315

Susquehanna River to Be Developed at Conowingo.....315

New Plant for Kansas Power & Light Co......315

News Notes.....315

Catalog Notes.....316

Published on the 1st and 15th of each Month by the

Technical Publishing Co., 537 So. Dearborn Street, Chicago

New York Office, 150 Nassau Street

Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents. Copyright 1925, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations

Circulation of this Issue 23,450

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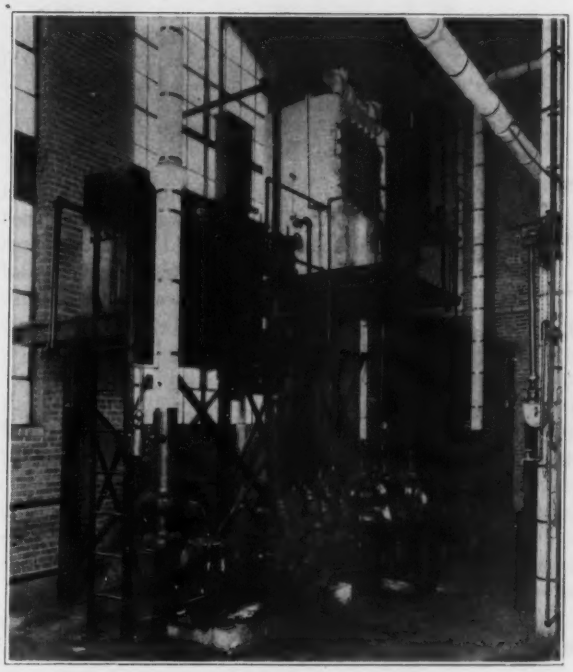
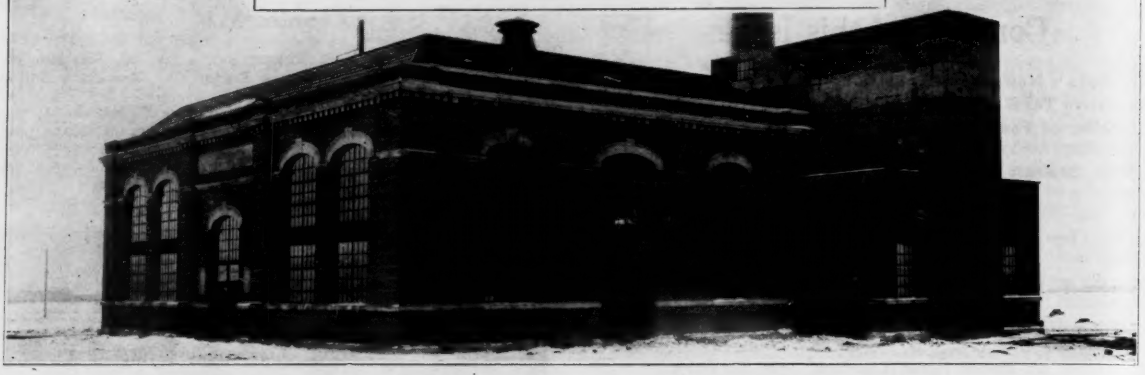


Let There Be Light

SUPPOSE THAT the windows in the above picture were bricked up and the platforms merely makeshifts instead of sturdy steel, and suppose further that the aisle at the right of the pumps was done away with. It would not make a pleasant picture and still not an unusual one as power plants go. Feed pumps and heaters constitute the heart of a plant and still most layouts show an absolute lack of appreciation of the requirements of operation and maintenance. Now, study the above picture as it actually is. Note the daylight available; there is plenty of space to dismantle a pump; overhead equipment is rigidly and permanently supported; the aisles are wide and clear and, above all, the "heart" of this plant is grouped so that the engineer can see not only every part of it at a glance but he can get to it to determine its pulse. There is a great deal to be learned from this picture, which is of the heart of the plant described in the article beginning on page 270 of this issue.

South Bend's New Pumping Station

LOCATION OF OLIVER PARK PUMPING STATION WAS BASED ON THE DIRECTION OF GROWTH OF THE CITY



FEW PEOPLE GIVE much thought to the subject of how their supply of city water is furnished to them and how much thought and study must be applied in order that they may be assured of an adequate supply not only as a matter of ordinary daily consumption but also to protect their property against the hazard of fire. The industrial executive carefully places his power plant so that it is advantageously located with respect to the load. We are all familiar with the term load center as applied to the location of central stations or group of public utility holdings, still we would be surprised to know that a pumping plant is not always located near a body of water but that it may be and often should be located, with respect to other plants in the same system, where it can best be adapted to the load which it is to assume.

Oliver Park pumping station at South Bend, Ind., is an excellent example of this type of engineering. At the time that this plant was being planned the city plan commission was making an extended survey of the city to determine the present density of population and also to find out in what directions it was most probable that the city would grow. This work was supplemented by the city authorities so that when the survey was complete, it was comparatively an easy matter to locate the new pumping plant so it would be directly in the path of the city's growth and thus serve its purpose in the best possible way.

It is interesting to note that the directional growth of South Bend is influenced at the present time by a river, which at least for the present, forms somewhat of a natural barrier and several large tracts of land which are privately owned and which are now used for such purposes that it is reasonable to assume that they will remain as such for a great many years to come. There is a remote possibility, of course, that ultimately South Bend will reach out beyond these barriers; however, when that time comes other plants will have to be constructed to take care of that increase in the size of the city. For some years to come the Oliver Park Station, located in the southwest portion of the city, will amply take care of the growth of South Bend.

Two other stations are now operating in conjunction with this new station. One of these stations is known as Central Station and it was originally built in 1873; having become obsolete, however, it was rebuilt about 1920 and now contains two 2,000,000 gal. per 24 hr. and two 3,000,000 gal. per 24 hr. centrifugal pumps. These were furnished by the Worthington Pump & Machinery Corp. and they are driven by Westinghouse Electric & Mfg. Co. motors, which are operated by 2300 v., 3 phase, 60 cycle, the current being furnished by the Indiana & Michigan Electric Co. Water for these pumps is obtained from 33 wells from which may be obtained a daily output of 6,000,000 gal.

"North Steam Station" is the name used to designate the second of the two old stations. As the name implies, it is a steam-operated plant, the units in which consist of two 5,000,000 gal. per 24 hr. each, Allis-Chalmers Mfg. Co., direct acting crank and flywheel, Corliss units and one General Electric Co. turbine, which drives an Aurora centrifugal pump, which is rated at 8,000,000 gal. per 24 hr. The boiler equipment at this station consists of two 150-hp. Babcock & Wilcox Co. water-tube boilers and two 300-hp. Freeman Mfg. Co. boilers, all of which are fired by means of Jones underfeed stokers which are made by the Riley Stoker Corp. The boilers furnish dry-saturated steam at 150 lb. pressure.

Water for this station is obtained from forty-seven 125-ft. wells, which have a daily capacity of 12,000,000 gal. A water storage capacity of 6,000,000 gal. is provided at this station, which was built in 1913, at which time South Bend had a population of about 55,000, whereas its population is now about 97,000.

As previously stated, one of the prime functions of a pumping plant is to have assurance that it will function properly during times of emergency, that is, when demands are made upon it to supply an extra amount of water in the event of a fire. A serious fire in a pumping plant would most assuredly be a calamity within itself and for that reason it is advisable to use fire-proof material throughout.

This has been well taken care of at the Oliver Park Station. The foundations and all floor work are of concrete. The walls are of brick and the outside trim is of Indiana limestone. The construction of the brick walls offered an opportunity for economy by shopping around and selecting a satisfactory brick, which well serves its purpose of durability and appearance at less cost than for matched face brick, which is so often specified.

Roof Slabs Were Poured in Place

Roof trusses are of steel and completely encased in concrete. The roof slabs are of reinforced concrete, which was poured in place. This construction eliminates all wood from the construction of the building and thus reduces the fire hazard to a minimum. The roof slopes back from the walls and then flattens out. The sloping part of the roof is finished off in tile, which adds greatly to the appearance of the building and the flat portion is covered over with Barrett composition roofing. The flashing and gutters are all made of copper in order to insure their permanency.

One interesting feature in connection with the construction of this station is that of the nature of the ground on which it is built. In the first place most of the digging for the foundation had to be done through wet and loose sand. It was, therefore, difficult to keep the hole dry and it meant that without care a great deal of trouble would be experienced due to seepage through the walls. Accordingly, the cement, sand and gravel were carefully tested and graded and the concrete was carefully worked in the forms so as to provide a dense wall. The result has been that practically no seepage water gets into the station and it was not necessary to waterproof the outside of the wall, that expense having been eliminated.

Water supplied by this station is taken from twenty-four 12-in. wells which are about 155 ft. deep and were drilled on either side of a gathering pipe, which is about 1100 ft. long. A connection is made from each well to this gathering pipe, which discharges into a reinforced concrete pumping well, which is 20 ft. in diameter by 48 ft. deep. One suction line extends to a garage building, which housed a temporary pumping unit used during the construction period. Another suction line leads to the pumping units in the main station.

These suction lines must of course be submerged well below the level of the water in the pumping well. A head must be maintained on these suction openings, regardless of the rate of pumping or the rate of natural flow from the wells. To accomplish this, there have been installed in the pump room of the station two direct-acting, steam-driven vacuum pumps which are used to maintain a vacuum in the gathering pipe which siphons to the bottom of the pumping well. The purpose of this arrangement is, of course, to maintain the priming in the siphon, which results in a lowered pressure against which the wells must flow with the result that an increase in the vacuum maintained will accelerate the rate of flow from the wells.

Use of Vacuum Pumps Is Not Always Necessary

It has been found that with the present rate of natural flow from the wells and also due to this siphoning action, it is not necessary to operate the vacuum pumps with one pumping unit operating at normal speed. The older unit of the two vacuum pumps is a Dean and it is the unit which is ordinarily operated. The other vacuum pump is new and it is used as a spare. It is a Burnham type of pump as made by the Union Steam Pump Co. The vacuum required to start the siphon is from 6 to 10 in. of mercury.

Main entrance to this station is from the east, directly into the pump room, which extends east and west, and occupies the south half of the building. The pumping or suction well is located a short distance from the west wall and about on a line drawn east and west through the center of the pump room. The boiler room occupies the north half of the building and the stack is set on a line with the suction well and is slightly to the north of the partition wall, which separates the pump and boiler rooms.

Just outside of the north wall is the coal and ash track,

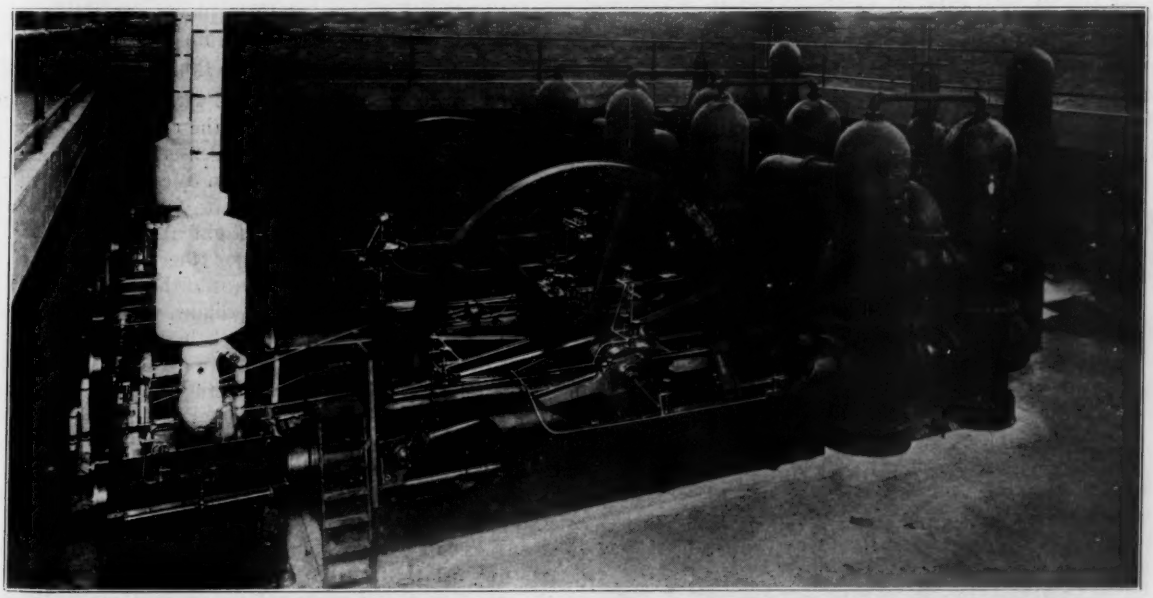


FIG. 1. TWO CRANK AND FLYWHEEL PUMPING UNITS HAVE BEEN INSTALLED. FUTURE UNITS MAY BE OF THE CENTRIFUGAL TYPE

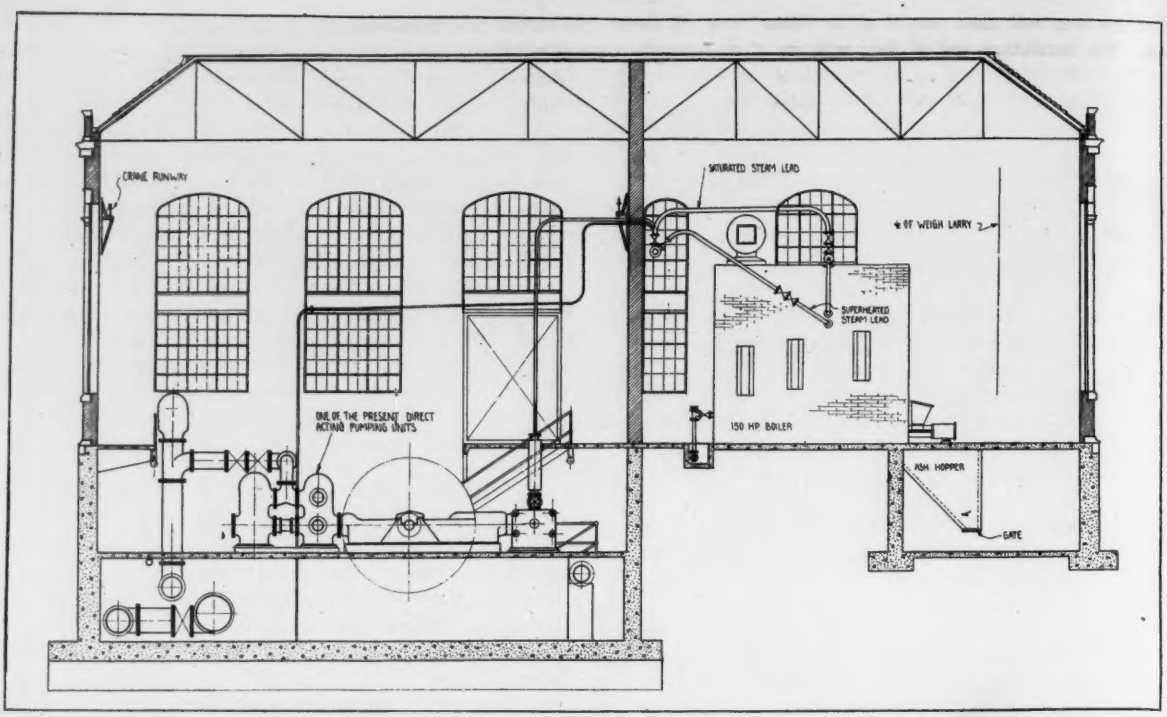


FIG. 2. EITHER SATURATED OR SUPERHEATED STEAM MAY BE USED IN THE PUMPING UNITS

which passes over a track hopper and coal and ash handling layout, which was constructed at the northwest corner of the building.

Entrance to the pump room may be gained from the front or main entrance to the building or through either of two doors located at opposite ends of the boiler room. The operating floor level on which the pumps are placed is below the ground level outside the building and also below the boiler room operating floor level. As you enter the pump room on the ground level, you stand on a gallery which extends around three sides of the room. The west side of the room is not provided with a gallery for it is there that a large double door is placed through which large pieces of equipment may be handled. The walls are finished off with a light brown colored glazed brick which, when contrasted with the concrete work, gives a pleasing appearance to the room.

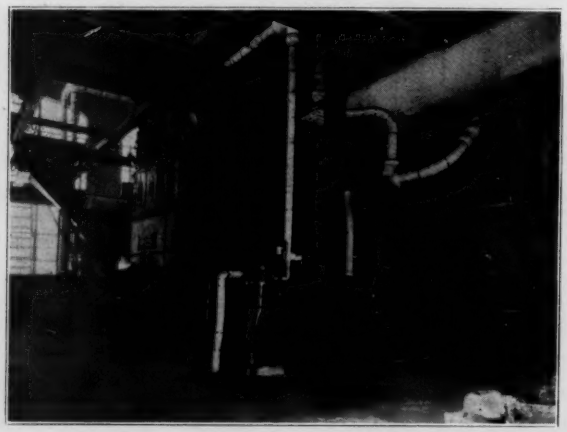


FIG. 3. WEIGH LARRY DISTRIBUTES COAL TO THE BOILERS

At present two pumping units are in operation. These are Allis-Chalmers Mfg. Co. crank and flywheel units, each rated at 5,000,000 gal. per 24 hr. They are compound units on which the high pressure cylinders measure 16 by 36 in. and the low pressure cylinders measure 36 by 36 in. They are equipped with Corliss releasing valve gear and operate normally at 33 r.p.m. against a head of 70 lb. The governors are so constructed that they may be quickly adjusted to maintain a water pressure of 120 lb. which is required in the event of fire.

The city fire alarm system is tied in with the pumping plants so that the crews at these plants are notified of a fire as soon as the alarm is turned in.

Water Works Type of Surface Condensers Are Used

Each pumping unit is equipped with a direct-connected condensate pump, which removes the condensate from the water works surface type of condenser, one of which is located in each of the water suction lines just ahead of the pump. These condensers maintain a 27-in. vacuum and can be charged only with a slight friction loss of the water passing through them for the condensing water passes on to the pumps and then into the city mains.

All condensate from each condenser is first passed through a heat exchanger, which is located in the exhaust steam line between the low pressure cylinder and the condenser. By this means, the temperature of the condensate is raised from 60 to about 90 deg. F. From the heat exchanger, the water is delivered to an overhead storage tank, which is located above the heater in the boiler room.

It is interesting to note that the temperature of the water from the wells does not vary much from about 56 deg. F. This fact, combined with the great excess of condensing water, as compared to that ordinarily required for the same amount of steam to be condensed, makes the condensing problem in a plant of this kind a comparatively simple one. The temperature of the condensing water is

raised but a fraction of a degree in passing through the condensers.

Each engine cylinder is equipped with a Richardson-Phenix lubricator, which pumps oil to six points in the cylinder and valves. A hand-operated pump has also been supplied. Lubrication of the bearings is taken care of by means of gravity feed from an overhead tank located in the pump room. Each distributing line is fitted with sight feed fixtures and as an auxiliary source of supply, each distributor pipe is fitted with an oil cup. All bearing oil drains into a continuous type of Bowser filter from which it is returned to the overhead tank for redistribution.

It is, of course, necessary to maintain a certain amount of air in the cushioning chambers on the pumps and accordingly a Westinghouse 8 by 8 by 10-in. air-brake type of air compressor has been installed. This is not operated automatically, but is started and stopped by the engineer in charge, whenever, in his judgment, more air is required.

The question might be raised as to why crank and flywheel pumps were installed and the answer is that the efficiency curve of these pumps is extremely flat over a wide range of load, therefore they prove economical under variable load operation. The pumping load for South Bend runs somewhat as follows; minimum demand 3,500,000 gal. per 24 hr.; minimum day demand 4,500,000 gal. per 24 hr.; average day demand 8,500,000 gal. per 24 hr.; maximum day demand 12,500,000 gal. per 24 hr. and the maximum emergency demand is at the rate of over 30,000,000 gal. per 24 hr.

Space still remains in this room for two more pumping units, which will be probably of the centrifugal type and turbine driven. It is probable that one of these units will be rated at 5,000,000 gal. per 24 hr. and the other unit will be rated at 10,000,000 gal. per 24 hr.

At the present time but two boilers are installed, being set in a battery and placed so that the rear of the setting is near the partition wall, which separates the pump and boiler rooms. These are Union Iron Works water tube boilers, each being rated at 150 hp. and designed for 175 lb. working pressure. The front header is set 7 ft. above the top of the stoker bed and the baffling is arranged vertically for three passes of the gas. Just above the first pass and below the boiler drum is located a Foster superheater, designed to raise the temperature of the steam about 75 deg. F. Bayer geared-head, soot-blower units are part of the boiler setting equipment.

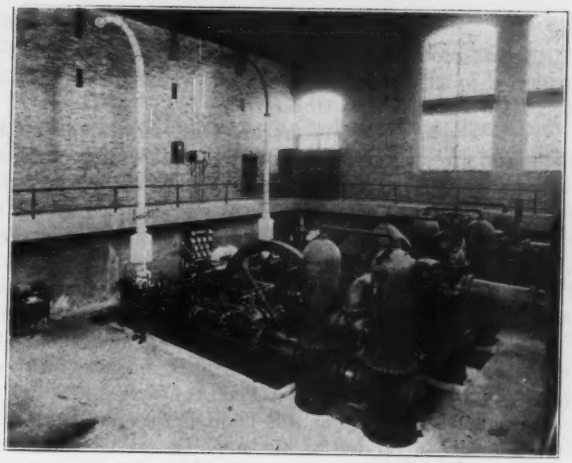


FIG. 5. BALCONY SHOWN IN THIS PICTURE IS AT THE LEVEL OF THE BOILER ROOM FLOOR

Automatic Control Will Be Installed

Feed water regulators have not been provided but the control of the dampers and stoker and fan speeds will be automatic. Each boiler setting is provided with a Hayes differential indicating draft gage and a Foxboro-Heath recording CO_2 meter has been installed at a convenient point in the pump room.

The blowoff tank is made of welded steel plate and is embedded in 6 in. of concrete. The breeching inside of the boiler room is made of ¼-in. steel plate and is 4 ft. in diameter. That portion of the breeching between the building wall and the stack is made of reinforced concrete. The chimney, which is of radial brick construction and was built by the H. R. Heinicke Co., is 5 ft. in diameter at the top and is 150 ft. high. It is of ample capacity, as is the breeching, to take care of two more boilers for which room has been provided in the present boiler room. Each boiler is fired with Illinois and Indiana screenings by a single retort Detroit stoker. One Troy

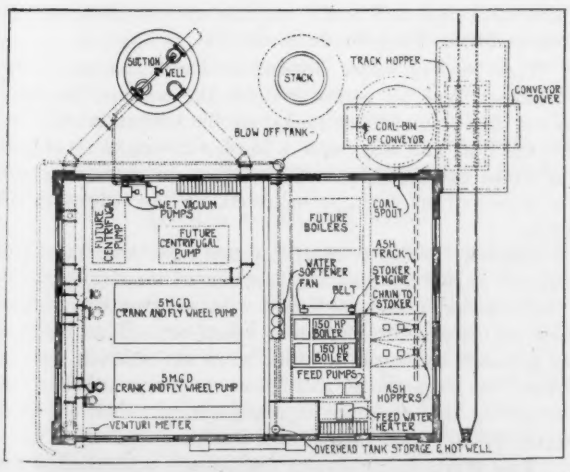


FIG. 4. COAL IS SPOUTED TO THE BOILER ROOM FROM THE SILO STORAGE BIN

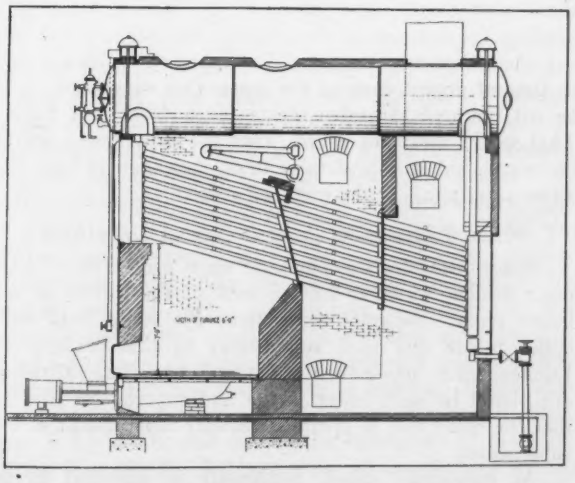


FIG. 6. BOILERS ARE BAFFLED VERTICALLY AND PROVIDED WITH SINGLE RETORT STOKERS

engine is chain connected to a common drive shaft from which both stokers are driven. This engine is also belt-connected to a No. 45 Clarage blower which furnishes the forced blast for the two stokers.

These single retort stokers are built with side dump plates and are set so that the ash and clinker drops into a comparatively small compartment below the stoker. It must then be raked out to the front and dropped through openings in the operating floor to an ash hopper or storage hopper located beneath the aisle of the operating floor. This hopper is suspended in an open passageway or basement along the floor of which is an industrial track. A dump car loads up with ash from the hopper and is pushed to the end of the basement where it is unloaded into a chute which discharges onto a Peck conveyor.

One unusual feature of this plant is that either superheated or dry-saturated steam may be taken from the

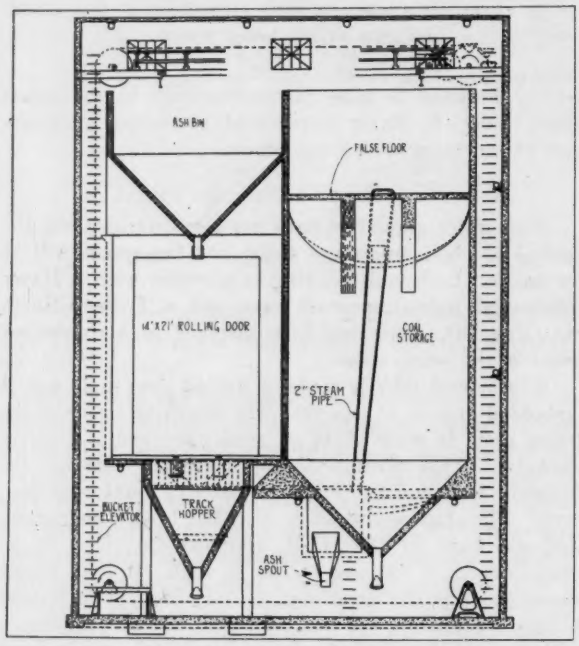


FIG. 7. ONE BUCKET CONVEYOR HANDLES BOTH COAL AND ASH

boilers. The reason for this arrangement is the fact that there must be no interruption of this station when it is meeting the demands of fire service. Normally, it will use superheated steam, however, if a superheater should fail in time of urgent demand for steam that superheater will be cut out and saturated steam taken from that boiler. That would mean, of course, that the superheater would be ruined, but it is preferable to do that than to have the water supply fail in the event of a fire.

Steam Leads from Boilers Are in Duplicate

Steam leads for the pumping units are taken off of a main header, which is located back of the boilers in the boiler room. Separate connections are made from each boiler nozzle and each superheater to this header. A Lunkenheimer non-return valve and two shut-off valves are placed in each boiler nozzle and superheater lead so that the boiler can be operated entirely independent of the superheater.

As previously stated, condensate is delivered to an overhead tank in the boiler room from which it flows by gravity to the Worthington open type feed water heater. Make-up water is taken from the well supply and first passed through a Wayne Tank & Pump Co. softener and then discharged as needed into the storage tank. The heated water flows by gravity to a Yarnall-Waring V-notch meter and then on to the feed pumps, which are located directly below the meter.

The Wayne water softener installed at the Oliver Park station is of the single unit vertical type, with automatic brine tank. The softener unit is 36 in. in dia. and 48 in. high. The brine tank is 30 in. in dia. and 48 in. high. The brine tank used in this installation holds sufficient salt to provide enough brine to regenerate the unit 26 times. Approximately 8 gal. of saturated brine is used each time the unit is regenerated. The brine tank is equipped with an automatic control which restores the salt solution to its proper level in the tank after brine has been drawn off for each regeneration process.

Once the softener is regenerated and ready for service, it will soften 2550 gal. of water before it needs to be regenerated. This softener is capable of delivering a maximum flow of 1000 gal. of soft water per hr., operating on water of 16 gr. hardness per U. S. gallon. The softener may be regenerated in from 20 to 25 min. This regeneration, largely automatic, consists of three operations. The first step in the regeneration is backwashing, by which water flows from the bottom of the softener up through the gravel and mineral bed, thus cleansing the mineral and removing all the solid matter which has been taken out of the hard water by filtration through the mineral.

Next, brine is passed from the brine tank to the softener, downward through the mineral bed to a drain. The mineral in the softener takes up the sodium in the salt and gives up the elements of lime and magnesia which it has removed from the hard water. The lime and magnesia passes out of the softener in the form of chlorides, which are soluble and will not clog the drain.

Then, when the required amount of salt has been put into the softener, raw water is passed downward through the mineral bed and flushes out all traces of salt through the drain. During the flushing process the water level in the brine tank is being restored. The refilling action in the brine tank is so gaged that flushing of the softener is automatically stopped when the proper level of brine is reached. This is accomplished by the use of a copper float in connection with a hydraulic valve. The raw water inlet valve and soft water outlet valve are then opened, thus restoring the softener to service.

This type of water softener is known as the "base-exchange" type, so named because the mineral employed as the softening element exchanges the sodium it contains, for the lime and magnesia in hard water until its softening properties are exhausted, and then, in turn, exchanges the lime and magnesia, so collected, for the sodium in the brine.

Capacity of the softener depends upon the amount of mineral it contains and the hardness of the supply water. Each softener unit is equipped with a meter which registers the amount of soft water taken out. This meter is so adjusted and arranged that when the softener has delivered its capacity of soft water, an electric bell rings, indicating that the unit is ready for regeneration. The water flowing from the softener is of zero hardness.

Two Worthington duplex feed pumps are installed and so piped that they may take water from the heater, from the storage tank or directly from the city mains. Exhaust

steam from the pumping units passes through Lagonda oil separators. All high pressure drips are connected to a pump, which forces this water through a Permutit filter before delivering it to the storage tank. Condensate from the main units also passes through this filter. The basement of the pump room is below the sewer, thus all drainage is raised by a simple, direct acting Union steam pump.

Coal is delivered to this station by rail, the cars being dumped into a track hopper located at the northwest corner of the building. Directly above this hopper is a reinforced concrete bin, which is used for ash storage. Just south of the hopper and forming a portion of the ash bin structure is a silo type of coal storage bin. A Link-Belt Co. bucket conveyor passes beneath the coal bin and the track hopper and the upper run passes over the ash bin and the top of the coal bin.

Ash is dumped slowly from the industrial cars previously mentioned, on to a grid which holds back large clinkers. Below this grid is a chute which delivers the ash to the lower run of the conveyor, which in turn delivers the ash to the storage bin over the track hopper. A railroad car spotted at that point can be loaded with ash from the overhead bin. The track hopper is provided with gates so that the coal may be fed at the proper rate to the lower run of this conveyor. The coal is elevated and discharged into the top of the coal storage bin, which is constructed with a false floor near the top.

This floor slopes and does not cover the full area of the bin so that as coal is unloaded by the conveyor, it piles up on the false floor to a certain height and then overflows through the opening in this floor and starts to pile up in the bottom of the storage bin. A spout from the lower end of the false floor extends through the boiler room wall at such a height that coal can be delivered by it to a Link-Belt Co. weigh larry which distributes the coal to the stoker hoppers.

The bottom of the coal storage bin is conical in shape and is provided with a gate so that the coal which has overflowed can be fed to the conveyor, elevated again and unloaded on the false floor for distribution to the stokers. In this way all of the coal in the bin can be removed. The two vertical runs of the conveyor are housed in a concrete structure which forms a part of the coal and ash storage structure. The conveyor is driven by a steam engine which is located near its upper run.

Description of this pumping plant was obtained through the courtesy of John W. Toyne, engineer for the City of South Bend, Ind.

Evaporative Tests at River Rouge

Results of Five Tests, Using Pulverized Coal for Sustained Boiler Loads Up to 285 Per Cent of Normal Rating

BOILER NUMBER 1 at the River Rouge plant of the Ford Motor Co. is one of eight 2647-hp. Ladd water-tube boilers. Each of these boilers really consists of two boilers of 13,235 sq. ft. of heating surface set over a single furnace. The furnaces which are of Lopulco design are of solid wall construction and have no water screens. The volume of their combustion space is 13,200 cu. ft. each. The furnaces may be fired with pulverized coal, blast furnace gas or coke oven gas used separately or in combination. Under ordinary operating conditions pulverized coal and blast furnace gas are used together. The tests outlined in this article were numbered one to five inclusive and were made when only pulverized coal was burned.

Pulverized coal is fed to 12 round-nozzle Lopulco 3½-in. burners by 12 Lopulco 5-in. feeders each driven by a variable speed electric motor. The burners are located six on the east and six on the west side of the furnace and fire downwards through suspended arches over dutch ovens. Blast furnace gas can be fired at a lower level through four Lopulco blast furnace gas burners. Coke oven gas may be introduced into the furnace through burners, one located under each of the four blast furnace gas burners.

Method of Making Tests

Five tests were run to determine the combined efficiency of the furnace, boiler and superheater when pulverized coal was the fuel. The water fed to the boiler was weighed in three tanks, each of 7000 lb. capacity, each resting on platform scales. The weighing tanks had conical bottoms and could be emptied rapidly and completely through 7-in. "quick-opening" valves. Each tank was fitted with a gage glass, permitting easy observation of the water-level in the tank.

Feed water entered each of the two lower drums of the boilers through two feed connections per drum. Thermometers in wells in each of these four lines measured the temperature of the water as it entered the boiler. The water entered the boiler 18 in. beyond the thermometers. A mercury thermometer, previously calibrated by the U. S. Bureau of Mines, in a well at the immediate outlet of the superheater measured the temperature of the superheated steam. The temperature of the exposed stem of this thermometer was also read on an attached thermometer and proper corrections were made to allow for a difference between the actual immersion of the thermometer and the immersion for which the Bureau of Mines calibration was made. A pressure gage of the Bourdon type was employed to measure the pressure of the steam at the outlet of the superheater. The instrument was calibrated before and after the tests. It was so located that it was not necessary to correct the actual readings for water leg.

Pulverized coal was weighed in four conical hoppers each of 1000 lb. capacity suspended from platform scales. These hoppers were located under the screw conveyors which supplied them with pulverized coal and above the pulverized coal storage bunkers into which they discharged. Canvas was employed to make the joints between the weighing hoppers and bunkers and conveyors dust tight. For each tankful weighed a sufficient amount of coal was taken from the proper one of the four sampling points to make a sample of about 100 lb. every 4 hr. The 100-lb. sample was well mixed and reduced to 3 gal. and this sample was divided equally between three air-tight shipping containers. The containers were well sealed, marked for identification and disposed of as follows: One sample was sent to the laboratory of the Milwaukee Electric Railway & Light Co. and one to the laboratory of the Ford Motor Co. for the determination of the fineness of the coal, the moisture, ash sulphur and heat value.

Composites of all the samples taken in each of the first

three tests were sent to the Pittsburgh Testing Laboratory and the laboratory of the Milwaukee Electric Railway & Light Co. for the determination of the total carbon and hydrogen in the samples. The third sample was stored away to be analyzed at any time in the future in case of a marked difference between the analyses of the first two samples. It was found advisable to use this sample because of a divergence between the results of analyses of the first two samples. One half of the umpire samples were analyzed by the laboratory of the University of Michigan and the previous laboratories repeated their work on their samples. These later results were found to check satisfactorily.

Slag or refuse dumped from the bottom of the furnace was sampled and the samples analyzed for combustible. Samples of such refuse as settled out in the last passes of the boiler were collected whenever sufficient quantities could be found. It is unlikely that the samples thus collected truly represented the ash passing through the boiler and out of the stack. They were analyzed, however, and the results applied in computing the heat balance. The particles making up these samples were coarse and contained coarse particles of coked black material which easily separated from the bulk of the ash which was a light grey and oftentimes almost white.

Flue Gas Composition and Temperature

Flue gas samples were taken and analyzed with Orsat apparatus for CO_2, O_2 and CO at six points below the boiler dampers. At the same locations flue gas temperatures were taken with six copper-constantan thermocouples. The temperatures were read with Leeds Northrup Potentiometers whose cold junctions were kept at the temperature of melting ice in thermos bottles. Two gas samples were taken and analyzed every fifteen minutes so that a sample from each location was analyzed every forty-five minutes. Temperature readings at all of the six points were taken every fifteen minutes. Drafts in the furnace, at the uptake under the dampers, at the base of the stack, above the dampers, and at the entrances to the second and third passes were taken with Ellison draft gages. The readings of the several gages were reduced to the same

TABLE I. DATA AND RESULTS OBTAINED ON FIVE TESTS WITH PULVERIZED COAL

Item			Pulverized Coal				
0	Test No.		1	2	3	4	5
1	Date of test		Nov.1,2,'23	Nov.5,6,'23	Nov.7,8,'23	Dec.5,6,'23	Dec.6,7,'23
2	Duration of test	hr.	30.58	31.00	32.07	23.82	24.03
24	Rating	Per Cent.	150.4	211.3	260.0	285.9	222.9
49	Efficiency	Per Cent.	77.8	79.6	80.9	82.2	82.1
	Pulverized Coal						
3	Fineness, per cent passing 200 mesh sieve	Per Cent.	76.2	72.8	73.3	76.0	77.0
4	Fineness, " " " 100 " "	Per Cent.	90.2	88.0	89.6	90.5	91.0
5	Fineness, " " " 50 " "	Per Cent.	97.8	96.4	96.4	97.2	98.0
6	Moisture in coal as fired	Per Cent.	2.0	3.2	3.2	3.4	3.2
7	Ash " " " "	Per Cent.	9.94	7.21	9.30	5.57	6.89
8	Sulphur " " " "	Per Cent.	0.53	0.67	0.71	0.71	0.68
9	Carbon " " " "	Per Cent.	73.69	73.65	72.75	73.4	73.4
10	Hydrogen " " " "	Per Cent.	4.50	4.69	4.42	4.5	4.5
11	Heat value per lb. coal as fired	B.t.u.	13,257	13,299	13,101	13,467	13,299
12	Total weight of coal fired during test	Lb.	394,854	549,404	697,552	545,556	438,892
13	Weight of coal fired, per hr.	Lb.	12,913	17,723	21,750	22,900	18,270
14	Lb. fuel fired per cu. ft. combustion space per hr.	Lb.	0.98	1.34	1.65	1.74	1.39
15	Heat liberated " " " " " " "	B.t.u.	13,000	17,800	21,610	23,400	18,500
16	Total wt. of water fed to boiler	Lb.	3,254,169	4,600,593	5,870,877	4,768,197	3,762,305
17	Water fed to boiler, per hr.	Lb.	106,419	148,406	183,065	200,176	156,567
18	Actual evaporation per lb. fuel as fired	Lb.	8.22	8.38	8.42	8.74	8.57
19	Absolute pressure of superheated steam	Lb.	242.5	244.2	239.5	237.8	246.4
20	Temperature of " " "	deg. F.	642	653	654	640	643
21	" " feed water	deg. F.	121.4	116.6	119.6	105.3	111.0
22	Heat added to 1 lb. steam in boiler and superheater	B.t.u.	1252	1263	1260	1267	1263
23	No. of boiler horsepower developed by boiler and suphr.	B. hp.	3980	5600	6895	7580	5905
24	Per cent of boiler rating " " " " "	Per Cent	150.4	211.3	260.0	285.9	222.9
	Air Temperatures - Pressures						
25	Outdoor temperature	deg. F.	47.0	45.2	34.6	40.9	36.6
26	Temperature of air supplied to furnace(Aver.boiler room temp.)	deg. F.	90.3	77.8	77.3	83.8	84.1
27	Barometer	Lb.	14.7	14.5	14.5	14.3	14.4
28	Pressure of primary air at feeders	in. H_2O	4.5	7.5	7.5	7.5	9.0
	Drafts corrected for elevation of points of insertion of gauges above that of gauge indicating furnace draft.						
29	Draft at base of stack	in. H_2O	2.38	2.75	2.84	2.77	2.76
30	Draft in east uptake	in. H_2O	1.27	1.68	1.89	2.15	1.63
31	" " west "	in. H_2O	1.30	1.82	1.88	2.14	1.65
32	" " furnace	in. H_2O	0.25	0.18	0.31	0.47	0.35
33	" at entrance into 2d pass east	in. H_2O	0.76	0.73	0.71	0.80	0.69
34	" " " " " " west	in. H_2O	0.76	0.73	0.72	0.80	0.68
35	" " " " 3d " east	in. H_2O	0.87	1.01	1.06	1.25	0.94
36	" " " " " " west	in. H_2O	0.84	1.01	1.06	1.27	0.99
37	CO_2 average of E. & W.	Per Cent by vol.	11.6	13.0	13.3	14.6	13.5
38	O_2 " " E. & W.	Per Cent " "	6.0	5.3	3.1	3.9	5.5
39	CO " " E. & W.	Per Cent " "	0.06	0.06	0.05	0.05	0.02
40	N_2 by difference	Per Cent " "	82.3	81.6	81.6	81.5	81.0
41	Temperature of flue gas, east uptake deg. F.	°F.	575	621	643	664	607
42	" " " " west " deg. F.	°F.	542	601	628	644	623
43	Average-temp. of flue gas E. & W. deg. F.	°F.	558	611	635	654	615
44	Lb. dry flue gases leaving boiler unit per Lb. fuel a.f.	Lb.	15.80	14.19	11.94	12.52	13.64
45	Excess air in " " " "	Lb.	37.6	32.3	16.6	21.8	34.6
	Ash and Refuse						
46	Carbon in furnace slag (by analysis)	Per Cent	0.05	0.03	0.02	0.00	0.00
47	Carbon " ash from last pass (by analysis)	Per Cent	-	4.04	12.04	34.79	11.97
48	Calculated total carbon in ash and slag	Per Cent*	0.21	0.20	0.78	1.36	0.58
	Heat Balance (Based on fuel as fired)						
49	Heat absorbed by water and steam (in boiler and suphr.)	Per Cent	77.8	79.6	80.9	82.2	82.0
50	Heat lost in dry flue gases	Per Cent	13.4	13.6	12.2	12.8	13.1
51	" " steam from H_2O and H_2 in fuel	Per Cent	4.0	4.4	4.5	4.3	4.2
52	" " due to incomplete combustion of CO	Per Cent	0.3	0.3	0.2	0.2	0.1
53	" " " " " of carbon in refuse	Per Cent	0.2	0.2	0.7	1.4	0.5
54	Radiation, errors and unaccounted for	Per Cent	4.3	1.9	1.7	0.9	0.1

* Based on fuel as fired

datum by correcting for the elevation of the points of insertion of the several gages above this datum.

Six thermometers located around the boiler and furnace under test were used to obtain the averages of the most probable temperatures of the air entering the furnace. The pressure of the air supplied to the feeders was measured with manometers. Outdoor temperatures were taken hourly as were also barometric readings. The flue gas temperature was measured at the entrances to the second and third passes. A throttling calorimeter in one of the two downcomers to the superheater was employed for estimating the amount of moisture in the steam delivered to the superheater by the boiler.

Starting and Stopping the Tests

Each test was started when the surfaces of the coal in all four necks of the bunkers were hoed down level simultaneously. Soundings were taken to determine the amounts of coal in each neck of the bunker. Tests were ended in a like manner. Suitable corrections were applied to the coal weights of each test for differences between the start and finish levels. The density of the coal used in figuring the corrections was taken as the mean of six trials. The coal levels were usually taken sufficiently low down in the bunkers so that errors in making the corrections for differences between the start and finish coal levels would not affect the accuracy of the total coal weights for the tests more than 0.2 to 0.5 per cent.

TABLE II. WORK DONE BY THE BOILER AND SUPERHEATER

Test No	1	2	3	4	5
Per cent of boiler Rating developed By boiler and superheater	150.4	211.3	260.0	285.9	222.9
Quality of steam entering superheater per cent	99.2	98.8	98.8	98.8	99.3
Heat absorbed by water and steam in the boiler per lb coal as fired, per cent	68.6	69.7	71.0	72.6	72.1
Heat absorbed by steam in superheater per lb. coal as fired, per cent	9.2	9.9	9.9	9.6	9.9
Efficiency of boiler, superheater and furnace based on coal as fired, per cent	77.8	79.6	80.9	82 2	82.0
Work done by boiler, based on total work done by boiler and superheater, per cent	88.2	87 6	87.8	88.3	87.9
Work done by superheater based on total work done by boiler and superheater per cent	11.8	12.4	12.2	11.7	12.1
Temperature drop of flue gas in first pass, deg. F.	1194	1253	1408	1247	1329
Temperature drop of flue gas in second pass, deg.F	173	184	182	326	185
Temperature drop of flue gas in third pass, deg.F	285	252	275	273	271

For all the tests in which pulverized coal was used mixtures of Pond Creek and Banner Fork coals were used. The mixtures delivered to the raw coal bunkers serving the Combustion Engineering Corp. Raymond pulverizers during the several tests were as follows (in tons):

	Kind of Coal	
Test No.	Banner Fork	Pond Creek
1	314	210
2	460	145
3	111	500
4	664	102
5	64	210

Pond Creek coal is mined from the Pond Creek seam near Stone, Kentucky, in Pike County. Banner Fork coal comes from the Wallins seam and is mined near Kentennia, Kentucky, in Harland County.

Coal was pulverized as taken from the storage pile or cars without previous drying and conveyed from the pulverizer building to the boiler plant with elevators and screw conveyors. The moisture in the coal varied between about 2 and 4 per cent and no difficulty was experienced in conveying it or feeding it to the furnaces.

Ash in the coal varied between about 5.5 and 13 per cent and contained considerable iron.

Because of the readiness of the ash to fuse it was found difficult to operate the furnace of Boiler No. 1 with low excess air. No provisions existed for cooling the solid walls, which in places are more than 2 ft. thick, nor are there any water screens in the furnaces. At ratings below 200 per cent the large cross section of the large furnace caused the gas velocities through the furnace to be low so that the furnace walls were, in a manner, subjected to soaking heats. The heat storage capacity of the thick walls was large and because of their thickness radiation from their outer surfaces did not help much in cooling them. Consequently when once the ash on the walls became fluid and dripping was imminent only bold changes in the furnace draft, that is bold increases of excess air were effective in preventing or stopping the dripping. Attempts to run with high CO_2 resulted in serious dripping of the walls and in Test No. 1 the slag for a short period became fluid enough to flow out through the ash pit doors. After freezing over the doors this slag could be removed from without and it was not necessary to shut down the test.

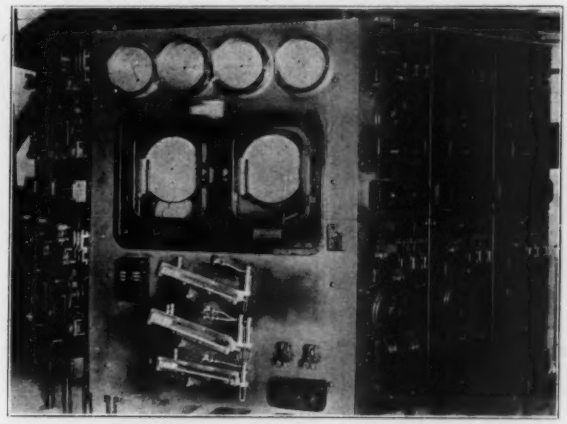


FIG. 1. INSTRUMENT AND CONTROL BOARD USED DURING THESE TESTS

Cracking and Spalling Developed in Arches

During Test No. 2 the arches which were made up of large blocks showed signs of cracking and spalling. The sharp corners of the nose tile were especially subject to cracking. During Test No. 3 after about 30 hr. of operation the spalling of the east arch had progressed so far that part of a flat arch tile just forward of the large steel girder from which the arch is hung and just north of the center of the arch fell into the furnace and exposed the girder to radiation from the furnace. Two hours of exposure caused part of the steel girder mentioned to assume a cherry red heat. To prevent any possible damage to this girder the test was closed after it had progressed 32 hr.

During Test No. 5 a patch of brickwork in the lower west corner of the south wall just above the third floor level became loose and fell into the furnace. This patch, 3 ft. high by about 5 ft. long was not part of the original lining but a repair patch placed there after a similar occurrence at some time in the past.

Pulsations Were Troublesome

When the draft in the furnace was held so as to give 14 per cent CO_2 or better there would arise, apparently without cause, pulsations at the rate of about 5 per sec. which caused flames to puff out through all openings in the furnace at every pulsation. The auxiliary air doors and all other doors which had some freedom of movement oscillated in resonance. Moreover, the rise and fall of pressure

FIG. 2. AIR FOR COMBUSTION IS ADMITTED TO THE FURNACE THROUGH THESE DOORS

within the furnace during the pulsations induced sympathetic vibrations in the air in the boiler plant so that all the doors and windows within the plant vibrated.

At first there seemed no certain method of stopping the pulsations. Sometimes increases in the draft reduced their violence. Often they disappeared without changes of any sort. The origin of these pulsations is obscure. It seems, however, that the tendency of the feeders to feed more coal during one part of a revolution than during some other part resulted in the condition that the richness of the coal-air mixture leaving the burner varied periodically during each revolution of the feeder. Consequently the velocity of flame propagation along the coal stream varied in a manner to cause the flame to travel up and down the coal stream as the velocity of the flame propagation for the mixture became greater or less than the velocity of the air-coal mixture.

It is possible that when two or more flames got into step and traveled up and down together the pulsations were set up. As more of the flames got in step the violence of the pulsations increased. It was found possible later to stop the pulsations by destroying the resonance effect by rapidly stopping several feeders for a few seconds and starting them up while several others were being stopped at the same time. This procedure disturbed the operation little and reduced the wear and tear on the furnace and boiler room equipment caused by the pulsations.

After Test No. 3 the original round nozzles were replaced with nozzles designed to double the velocity of the coal-air mixture. This was done in order to obtain better mixing and shorter flames. The new nozzles permitted the use of higher primary air pressures for the same flame length. Actually the modified nozzles improved the appearance of the flames which were sharper and brighter than before and did not have the "woolly" appearance previously observed. The flames from the new nozzles were about 2 to 3 ft. shorter than before under approximately similar con-

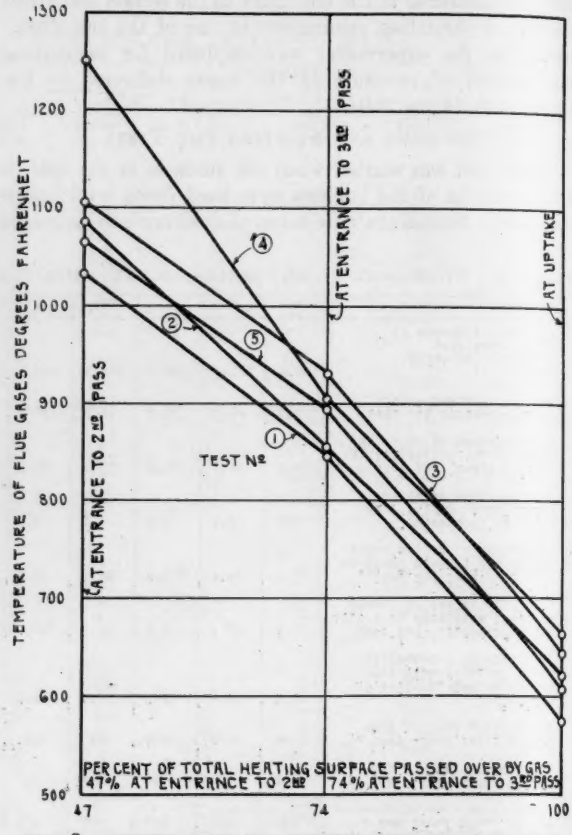


FIG. 3. CURVES SHOWING TEMPERATURE DROP IN THE VARIOUS BOILER PASSES

ditions of primary air pressure, rating and draft. The modified nozzles were used for tests Nos. 4 and 5. The nozzles near the side walls were turned towards the center of the furnace about 10 deg. so as to keep the flames from the side-walls.

During test No. 5 the bottom ash pit doors were kept open about 2 in. in order to keep the ash pit cool and to raise the flames above the "hump" between the two ash hoppers. This tended to shorten the flames by supplying air to the inner parts of the flames just after they turn up.

Data from which the first five tests with pulverized coal were computed are of such accuracy that the efficiencies reported herein are probably accurate to within plus or minus one per cent.

In the installation of steam lines it is essential to eliminate air and vapor pockets, as their presence will cause the lines to become air or vapor bound and greatly reduce the carrying capacities.

Don't expect your centrifugal pump to lift water if the glands leak and are not properly packed.

Application of Powdered Coal to Boilers

RECENT DEVELOPMENTS IN THE USE OF POWDERED COAL, GIVEN AT THE ANNUAL MEETING OF THE A. S. M. E. BY HENRY KREISINGER

THREE YEARS have shown a marked increase in the application of powdered coal to steam boilers with the result that at present no power plant designer decides on coal-burning equipment without making a thorough investigation of the possibilities of powdered coal. For large stations and for large steam-generating units the indirect system seems to possess an advantage over the direct-firing system and is generally favored for this kind of service, direct firing, however, seems to have some advantages in small industrial plants and small boiler units.

Powdered coal gives high efficiency because the coal can be burned almost completely with low excess air. Low excess air, however, causes high furnace temperature,

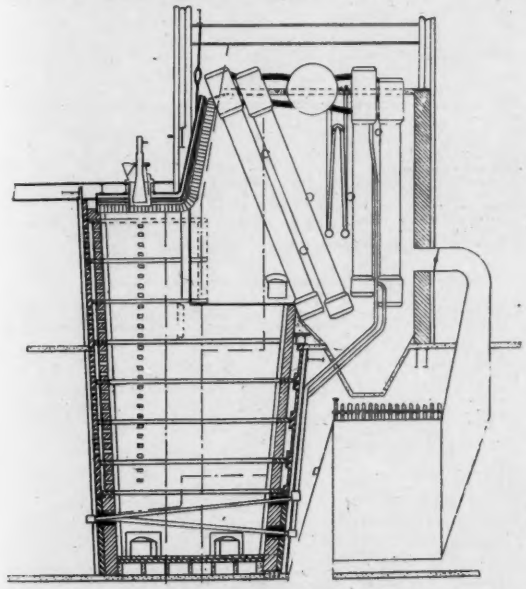


FIG. 1. POWDERED COAL INSTALLATION OF AN 8750-SQ. FT. BOILER AT PLANT NO. 3 OF THE ROCHESTER GAS & ELECTRIC CO.

which in turn causes fusion of ash and erosion of furnace lining. Many of the first attempts to burn powdered coal failed because of the excessive erosion of the furnace lining. Another cause of early failures was the difficulty of removing fused ash from the furnace. A large part of the ash was sprayed in a molten state on the walls and bottom of the furnace. The molten ash sprayed over the walls ran down, washing the brick along with it and accumulated in a puddle of molten slag at the bottom. This slag could not be removed without cooling the furnace and mining the slag out with picks.

At present, the trend of the development of the furnace is toward nearly complete water cooling. About 4 yr. ago a water screen was applied over the bottom of the furnace with the object of preventing fusion of the ash deposited on the bottom and of making its removal easy. This water screen met with such success that it was soon applied to the back wall of the furnace, where the abrasion was great, due to the turning of the flame. Water-cooled side walls are now used in addition to the screens over the bottom and back wall of the furnace.

[1]Research Engineer, Combustion Engineering Corp.

For greatly reducing the abrasion on the furnace walls, the hollow-wall construction has met with considerable success, especially with coal, the ash of which melts at a

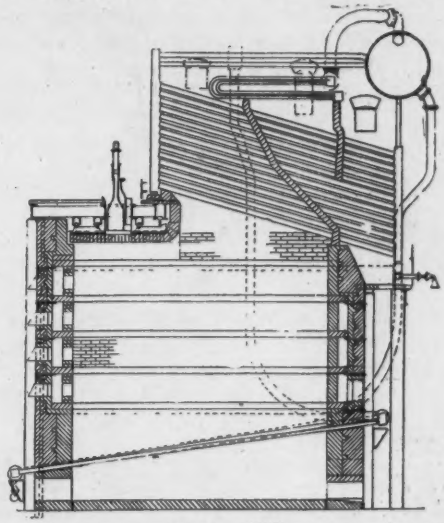


FIG. 2. CROSS-DRUM BOILER OF 822 HP. RECENTLY PLACED IN OPERATION BY THE PENN SALT CO.

comparatively high temperature. In this hollow-wall construction the walls are built with channels between the furnace lining and the outer wall and through these channels 60 to 80 per cent of the air needed for combustion is passed before it enters the furnace. The air passing through the hollow walls cools the furnace lining and greatly reduces its erosion by the molten ash. Many furnaces of this design are in use and are meeting with considerable success. It appears, however, that the water-cooled furnace is to be preferred where high ratings are desired and the coal has extremely fusible ash.

Hollow-wall construction has one commendable feature and that is no air inlets lead directly from the outside into the furnace, through which a flame might puff back into the boiler room and ignite an accidentally caused dust cloud. In the hollow-wall construction the air ports supplying air for combustion open into horizontal air channels. These usually pass halfway around the furnace so that the flame puffing out of the furnace would have to travel 30 to 40 ft. before reaching the outside of the setting. This feature also could be applied at least to some extent to water-cooled furnaces in order to make the operation of these furnaces safer.

It is frequently pointed out that pulverized coal requires large furnaces. This is undoubtedly true if the powdered-coal furnace is compared to old-type stoker installations which usually have a furnace with a comparatively small combustion space. When the comparison is made with the modern stoker furnace, the difference in size is not so great, in fact in the past, stoker furnaces were built much too small. In recent stoker installations attention is given to proper design of the furnace and we find stoker installations with 20 to 22 ft. between the stoker and the boiler tubes.

One other reason why the powdered-coal furnace seems large is that most of the powdered-coal furnaces have been

installed under extremely large boilers which are to be operated at high ratings, consequently the furnaces are made large. These large furnaces are likely to be compared with stoker or hand-fired furnaces of 10 yr. ago, when a boiler of 5000 sq. ft. of heating surface was considered large. In present-day power-plant practice steam-generating units of 30,000 sq. ft. of heating surface are quite common. It seems that for these large steam-generating units powdered coal is especially advantageous, because with powdered coal uniformly good combustion can be obtained throughout a large furnace and over a wide range of rating.

Moisture Must Be Removed from Some Coals

Some coals require drying in order to make them pulverize easily, to facilitate conveying and to make feeding of pulverized coal into the furnace more uniform. Other coals may be pulverized and fed to the furnace without drying. In general, coals from the Appalachian and Eastern coal fields may be pulverized and burned without drying. Coals from the Illinois and the Western coal fields must be partly dried before pulverization. The drier is always a nuisance, although sometimes a necessary one. In other cases it is not easy to decide between the difficulties of pulverizing and feeding undried coal and the expense and trouble of drying it. In some other cases it is comparatively easy to decide to omit driers. There are a number of plants operating with powdered coal which never have had driers installed.

Trend in the development of coal driers is toward a small drier that will dry coal to a sufficient extent as the coal moves toward the mill. Such driers are built in the form of an enlarged coal chute, the coal being dried either by waste gases from the boilers, or by exhaust steam. Such driers extract from 2 to 4 per cent moisture. Besides extracting moisture, they preheat the coal, so that when it gets into the mill and is pulverized, it readily loses moisture, and part of the moisture is discharged from the mill system through the mill vent.

TABLE I. RESULTS OF BOILER TESTS AT THE CAHOKIA PLANT OF THE UNION ELECTRIC LIGHT & POWER CO.

(Babcock & Wilcox cross-drum boiler, 18,010 sq. ft. of heating surface)

Test No.	2	3	4	5	6	7	8
Duration, hr.	25 35	21.88	25.48	20 20	23.05	21.18	10.80
Coal as fired							
Moisture, per cent	7.08	6 39	7 08	5.89	5.63	6.82	6.77
Ash, per cent	11.47	11.82	11 40	11.04	11.38	11.06	11.38
B.t.u. per lb.	11673	11553	11599	11802	11790	11713	11672
Fired per hour, lb.	8991	13267	8165	16187	11256	13161	17325
Per cu. ft. of combustion space per hr., lb	0.77	1 13	0.69	1.38	0.96	1.12	1.49
Ash							
Comb. in furnace ash	0.2	...	....	.....	.....	.....	.....
Comb. in flue dust	4.8	3.4	4.0	5.1	1.8	2.8	3.0
Water, lb.							
Evaporated per hour	75948	104458	66286	129779	90454	107114	133763
Evaporated per lb. of coal	8.45	7 98	8.18	7.99	8.04	8.18	7.63
B.t.u. per lb. of steam	1185.4	1203.8	1187 7	1213.3	1200.3	1210.6	1222.9
Temperatures, deg. fahr.							
Air to furnace	95	91	87	81	84	80	82
Air to feeders							
Gases leaving boiler	483	520	474	564	502	527	589
Feedwater	197	199	194	200	197	198	203
Superheated steam	670	707	668	727	697	718	750
Pressures, lb. per sq. in., abs							
Superheater	330	332	328	324	330	331	332
Drafts, in. of water							
Furnace	0.13	0.15	0.08	0.34	0.14	0.18	0.22
Uptake	0.37	0.70	0.20	0.47	0.56	0.80	1.60
Pressure feeder air	9 2	12.2	11.3	17.8	13.4	13.5	19.8
Analysis of gases, uptake							
CO_2	14 7	14.7	14.4	14 1	14.5	14.7	14.0
O_2	4 1	3.9	4 4	4 7	4.3	4.3	5 0
CO	0	0	0	0	0	0	0
Heat account in per cent							
Heat absorbed by boiler and superheater	85 9	83 1	83.8	82 1	81.8	84.5	79.9
Loss in dry gases	9 1	10.2	9.2	11.7	10.0	10.5	12.5
Loss in water vapor	5 1	5 4	4 9	5.0	4.8	5.0	5.0
Loss in incomplete combustion	0.6	0.5	0 5	0.6	0.2	0.3	0.4
Radiation							
Errors and unaccounted for	−0 7	+0 8	+1 6	+0 6	+3.2	−0.3	+2.2
Total	100 0	100 0	100 0	100 0	100 0	100 0	100 0

Driers using flue gas from the boilers are adaptable to plants where the coal preparation room is so close to the boiler plant that the gas ducts are not long. The amount of gas used in this type of drier is about 3 lb. per pound of coal dried. In other words, about one-quarter of the boiler flue gas is used for drying purposes. These driers are also adaptable only for plants where the flue-gas temperature is not lower than 300 deg. F. With plants having economizers which reduce the temperature of the gas below 300 deg. F., driers of this kind cannot be used.

Steam May Be Used to Dry Coal

Installations having the preparation room distant from the boiler plant and in plants where economizers are used, a steam drier possesses an advantage over the flue-gas drier. This drier is of the same general design as the flue-gas drier but the coal passages are made of steam-heated grids. As the coal passes through the drier it is heated and the moisture is partly evaporated. A small amount of air is drawn through the coal and this air carries the water vapor away. The amount of air used for this purpose is about one pound of air per pound of coal. This quantity of air is small and only a small pressure drop through the drier is necessary. The velocities are so low that no noticeable quantity of dust is drawn out with the air. In both types of driers more moisture is driven from the coal if the coal is of a smaller size; that is, coal passing through ¼-in. screen will dry better than coal passing through a 1½-in. and over a ½-in. screen.

Development of mills for large central stations trends decidedly toward higher capacity. Most of the mills at present used in central stations have a capacity of from 5 to 9 T. per hr. Some mills are now being installed which have a capacity of 15 to 18 T. per hr. The demand seems to be for a mill of about 50 T. capacity. The mills used at present are of the rolling type; that is, the coal is pulverized by rolling a metal roller or ball over the coal and in that way crushing it. A real impact mill is looked upon as having the possibility of being developed into a machine of high capacity, low power consumption and small wear.

TABLE II. RESULTS OF TESTS OF A 6-ROLL RAYMOND PULVERIZER

Illinois Coal [1]

Test No	1	2	3	4	5	6	7	8
Total mill hours	16.33	13.99	27 72	17.05	58.86	35 23	50 15	48 78
Coal per hour, tons	5 97	5 24	5.27	6.00	6.68	5 70	4 31	4 06
Moisture in coal, per cent	4 6	6 0	5.2	4 1	5 6	3 7	6 1	6 2
Kw per hour	77 5	78 0	77 9	78 3	79 3	78 7	77 2	77 4
Power per ton of coal, kw-hr	13 0	14.9	14 7	13 4	14 3	14 1	18 4	19 6
Average fineness of coal: Through 100 mesh 95 per cent, through 200 mesh 76 per cent								

Tests 1 to 6, dried coal, tests 7 and 8, undried coal.

Pennsylvania Coal, Natrona Mine, Undried [2]

Test No	1	2	3	4	5	6	7	8	9	10	11
Total mill hours	10 92	11 17	6.93	6.35	9 90	10 65	14 26	14 10	13 03	13 48	9 22
Coal per hour, tons	5 04	5 04	5.40	5.35	4.95	4.86	4.56	4.61	4 86	4 98	4 87
Moisture in coal, per cent	2 4	2 1	1 8	2 1	1 9	2 4	2 1	1 8	2 0	1 9	1 6
Kw. per hour	63 7	67.6	69 3	68.0	63.9	66 1	61.6	59 1	69.0	67 0	65 0
Power per ton of coal, kw-hr.	12.45	13.41	13 14	12 75	12 96	13.56	13.50	12 81	14.25	13 38	13 38
Average fineness of coal Through 100 mesh 95 per cent, through 200 mesh 76 per cent.											

New River Coal, Undried [3]

Test No	1	2	3	4	6	7	9
Total mill hours	8.6	6 8	5 1	5 8	5 8	4 6	5 6
Coal per hour, tons	9 9	8.85	8 8	8 1	8 7	8 3	7 1
Moisture in coal, per cent	2 5	2.9	2 6	2 7	2.6	3 1	2 6
Kw. per hour	112	106	104	99	105	105	87
Power per ton of coal, kw-hr	11 4	12 0	11 8	12.2	12 1	12 7	12 3
Average fineness of coal Through 100 mesh 98.5 per cent, through 200 mesh 81 5 per cent							

[1] Tests at St. Joe Lead Co., River Mines, Mo., November, 1921.
[2] Tests at Penn Salt Co., Wyandotte, Mich., July and August, 1923.
[3] Tests at United Rys. of Providence, Providence, R. I., May, 1924.

Reliable data on the cost of making steam with powdered coal are still meagre. It is to be expected that with many powdered-coal plants in operation more data on the cost of making steam soon will become available, so that it will be possible to make a fair comparison with the cost of making steam in stoker plants.

In the past, unfair deductions for powdered coal were often made by estimating the cost of preparing pulverized coal and then comparing it with the value of the coal saved by the higher thermal efficiency of powdered coal over the stoker. All comparisons should be made on the basis of total cost of preparing and burning pulverized coal and the total cost of burning with stokers.

Tests at the Cahokia power plant of the Union Electric Light & Power Co., St. Louis, Mo., were made on a Babcock & Wilcox cross-boiler drum, 20 tubes high and 38 tubes wide, with 18,010 sq. ft. of heating surface. It was equipped with a Babcock & Wilcox superheater of 4070 sq. ft. of heating surface placed in an inter-deck chamber above the sixth row of boiler tubes. The furnace was of the hollow-wall construction with a steel casing and it was equipped with 10 Lopulco fantail burners and a water screen over the bottom and rear wall of the furnace, with 587 sq. ft. of heating surface exposed to fire. The water screen consisted of 4-in. tubes spaced 10.85 in. between centers. It was connected to the boiler drum by two 6-in. downcomers and two 8-in. risers. The combustion space above the water screen was 11,750 cu. ft. The average distance between arch and water screen was 22 ft.

Coal used was Illinois coal of the following typical composition:

Moisture	12.91 per cent
Ash	11.64 per cent
Carbon	60.74 per cent
Hydrogen	4.00 per cent
Nitrogen	1.15 per cent
Sulphur	1.32 per cent
Oxygen	8.24 per cent
Volatile	31.9 per cent
Fixed carbon	43.55 per cent

The results of these tests are given in Table I and are typical of what is being done in a large central station with large units that are fired with western coal.

Colloidal Purification of Feed Water

By C. H. S. Tupholme

EFFICIENT generation of steam calls for a suitable feed water and since the waters usually available for use in the power plant are unsuitable for steam-raising, treatment is necessary before the water can be fed with confidence into the boilers. The chemistry of boiler feed water has made great strides during the last decade though few applications of new knowledge have been made since the utilization of the lime and soda process. Many mechanical improvements have been made in water softeners, and, under proper supervision, these machines are capable of giving exceedingly good results.

Hardness of water is due to substances which give it a temporary and a permanent hardness. It is usual to remove the temporary hardness by lime, either quick or slaked, or lime water. This treatment precipitates the bicarbonates of lime and magnesia in solution. Permanent hardness is treated by using soda ash in conjunction with the lime.

It is generally agreed that the best place to treat the feed water is outside the boiler, so that the deposits are away from it. This is especially important in small installations, though many prefer internal treatment of their feed water. In addition, water softeners are seldom effective below 5 deg. (parts per 100,000) and this is quite sufficient to cause a hard scale; also, few filters remove more than 80 per cent of the deposit, and, though the water may be clear, chalk probably is still present in the colloidal state.

It is likely that some simple definition of "colloid" would be of service here. A colloidal solution is one in which a finely divided substance is prevented from coalescing. For instance, such substances as salt and sugar are crystalloids, while starch and albumen are colloids. It is better to refer to the subject as being in a colloidal state, because some are colloidal in some solvents and crystalloidal in others.

It has been found that the particles of most colloids possess on their surface either a positive or a negative charge. This is an important property because if the charge can be removed the particles cease to be in colloidal suspension and are precipitated, the colloidal suspensions being known as sols and the colloidal precipitates, gels.

As far as a water softening plant is concerned, soda renders a proportion of the chalk colloidal against which filtering is ineffective. The heat of the economizers changes the chalk from its colloidal state into an ordinary deposit, which results in scale. This is why scale is commonly found in the hot end of economizer tubes. By the use of a colloid the insoluble matter in the feed water may be prevented from interlocking to form scale.

Dissolved oxygen and carbonic acid gas, if in excess, cause corrosion. If magnesium chloride is present the corrosion is accelerated. This salt is a common constituent of water, and at boiler pressures it splits up, giving free hydrochloric acid, which causes pitting and grooving. The remedy for this is deoxidation.

There are many theories of the corrosion of iron and steel, though these are not of such interest to the power plant engineer as the determination of a limit in which it will not take place. This is done by stating the hydrogen ion concentration of the water in terms of what is known as its P_h value, pure water having a P_h value of 7, the alkaline solutions having higher, and the acid solutions lower, values.

The maximum permissible density for a boiler feed water depends upon its salt content and alkalinity. Overtaxing of the softening plant causes the boiler to prime. An alkalinity of 50 to 70 deg. and a density of about 6 deg. Twaddle in Lancashire boilers and 4 deg. T. in Babcock or other water-tube boilers is safe.

It is generally accepted that the corrosion of boiler tubes, plates and economizers is due largely to the amount of oxygen in the feed water, the amount varying under different conditions. Distilled water at 68 deg. F. usually contains 8 cc. per 1000 cc., and raw water 6 to 7 cc., which is reduced at 212 deg. F. to 2 cc. It has also been shown that substances generally considered as being corrosive in boilers can be present even in large quantities, provided free oxygen is eliminated.

There is little doubt that as progress is made in the study of colloids and colloidal chemistry, greater advances will be made in the purification of boiler feed water, in which direction the use of colloids will find as great a field as in any other.

XUM

Multiple Exhaust Blading in Steam Turbines

DETAILS OF UNITS INSTALLED IN THE 35,000 KW. UNITS AT THE SPRINGDALE AND COLFAX STATIONS. BY P. C. EPPELSHEIMER*

IN LARGE TURBINES operating at a high vacuum there exists the problem of passing a great volume of steam efficiently through the last row of blades. Maximum allowable stresses limit the blade height and diameter

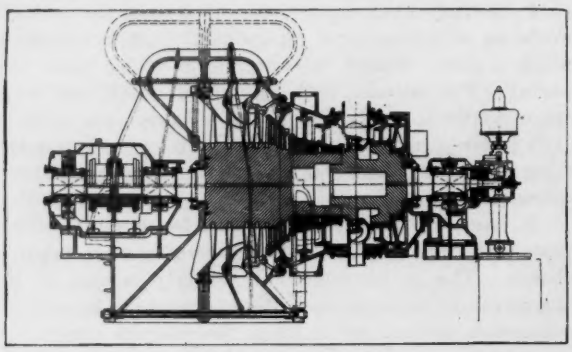


FIG. 1. CROSS SECTION OF 35,000 KW. TURBINE

which can be employed for a given rotative speed and this limit is considerably below the limit of generator capacity for the same speed. The double flow principle has been employed satisfactorily but this usually involves two exhaust outlets with expansion joints to connect them to the condenser.

With some recent large turbines built by the Westinghouse Electric & Manufacturing Co., the necessary area at

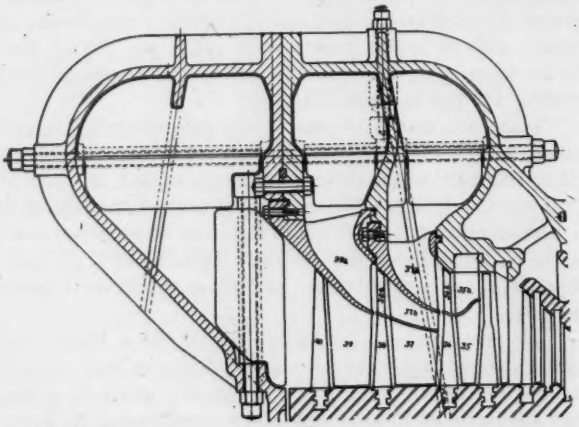


FIG. 2. CROSS SECTION THROUGH MULTIPLE EXHAUST BLADES

the exit side of the blading is obtained by an adaptation of the multiple exhaust principle devised by Karl Bauman of the Metropolitan Vickers Co.

In the 35,000-kw. units as installed in the Springdale and Colfax Stations, each of the last few rows of blading is provided with a partition which proportions the steam flow into tiers. Figure 1 shows a cross section of the turbine assembly while Fig. 2 is an enlarged section of the special blades. For reference the blade rows are numbered in the latter illustration, each having the actual number as they appear in the turbine.

*Westinghouse Electric and Manufacturing Co.

All portions of the blades forming the innermost tier, i. e., that nearest the spindle, are of reaction type, especially designed for low steam velocities and low pressure drops. The entrance angles vary along the length of the blades, this being done to compensate for the varying linear velocities so that the steam may enter the blade passages without shock and its consequent energy loss.

The first row of these special blades is No. 35. It is a stationary bronze blade fitted into the cylinder grooves in the usual way. The outer portion (35-A) is designed as an expanding nozzle which reduces the steam to con-

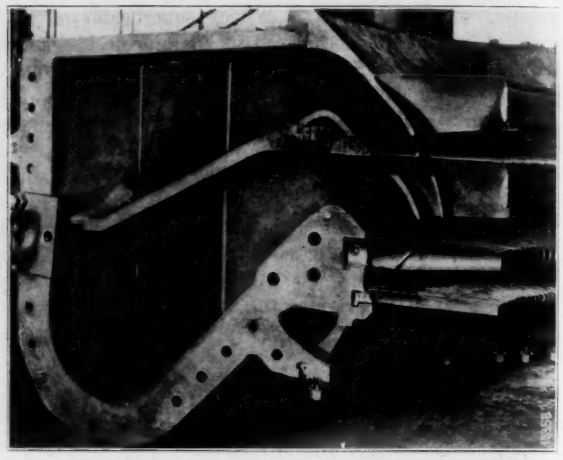


FIG. 3. VIEW OF LOW PRESSURE CYLINDER SHOWING STATIONARY BLADES AND GUIDE VANES

denser pressure. In this nozzle the same B.t.u. drop takes place as is distributed over all the reaction blades of the innermost tier. The partitions besides serving to divide the steam flow act as a tie between blades, reducing vibration.

Row 36 is a moving blade, drop forged from 5 per cent electric furnace nickel steel. The outer portion is of impulse type, so designed as to utilize the energy derived from the expansion of the steam in the nozzle (35-A) and deliver it to the exhaust chamber where it is guided by vanes in a stream line flow to the condenser. To minimize steam leakage between the tiers, the partitions on the entrance and exit sides are grooved and thin strips similar to dummy strips and which act in the same way are inserted. The root and partition are carefully machined and accurately fitted together.

Row 37 consists of 6 smoothly finished close grained iron castings. They are attached to the cylinder by heavy tap bolts as indicated in Fig. 2. These segments contain three tiers, the outer, or (37-a), consisting of widely-spaced vanes which serve to support the segment and to guide the steam from 36-a to the exhaust passage. The inner tier is of reaction design while the central tier consists of expanding nozzles to reduce its portion of the steam to condenser pressure.

Row 38 is a duplicate of row 36.

Row 39 also consists of 6 iron castings bolted to the cylinder, but unlike Row 37 there are but two tiers, the

outer one consisting of supporting webs or guide vanes. The steam entering the condenser from the outer tiers of rows 36 and 38 is just as completely and efficiently expanded as that which passes through the inner tier, entering the exhaust from row 40 and the total last blade exit area is that of row 40 plus the outer portions of rows 38 and 36.

For the purpose of illustration of this multiple exhaust the different tiers may be regarded as separate turbines, each with the same initial steam conditions and expanding to the same vacuum, but having different blade speeds. The outer tier having the greater velocity utilizes the larger B.t.u. drop allowed in them just as efficiently as does the inner tier with its lesser wheel speed and B.t.u. drop per row. The net result is greatly decreased blade heights necessary in the last rows as compared with standard single flow construction.

To increase further the efficiency of the low pressure end the exhaust chamber contains several guide vanes, both cast integral and built in, which guide the steam in stream lines from the last blade annulus to the condenser. This construction conserves the carry over velocity of the steam, reduces eddy currents in the exhaust chamber, and by insuring an even distribution over the condenser opening reduces the pressure drop between the blade outlet and the condenser to a negligible amount.

Boiler and Turbine Room Instruments

Recent Developments, New Adaptations of Old Instruments and Their Use in Obtaining Heat Balance Data

MANY INTERESTING expressions on the development and use of power plant instruments are contained in a recent report of the prime movers committee of the N. E. L. A. One instrument reported on was an indicating steam-flow air-flow meter, made by the manufacturer to replace the usual recording type of instrument. The user points out that he feels an instrument of this type serves merely as a guide to the fireman in his adjustment of draft and there is no great advantage in having a record of this performance, as with sufficient competent supervision in the boiler room the desired results can be maintained.

One company has experienced difficulty in the past in not having its switchboard operators thoroughly familiar with conditions in the turbine room and it has therefore developed two instruments which are new in their applications. One of these is the adaptation of the principle of an electric flow meter to indicate the vacuum at the switchboard. This company has also adopted the selsyn scheme of communication to indicate the governor position to the switchboard operator. The sending element is attached to the auxiliary spring compressor at the governor of the turbine by means of a rack and pinion. At the switchboard is installed an indicating dial with a pointer which will move through approximately 300 deg. from the upper to the lower limit-switch. With these two instruments, together with a steam pressure gage and wattmeters, the switchboard operator is able to analyze conditions rapidly during emergency periods.

Determination of Salt in Condenser Water

Potentiometers used for determining the salt content in the condensate or condenser leakage have come into general use. It is pointed out that in the use of these instruments it is necessary to have the calibration curves, that is, the curves showing the relation between ohms resistance and grains per gallon, based on a sample of the particular water to be used and that it is also necessary to have a temperature correction curve.

Buffalo General Electric Co. has reported on the design and use of a new instrument, developed by one of its staff, which is used for indicating air leakage in condensers. This is made up of a modified U tube, consisting of a long leg sealed at the top and a bulb for the short leg. This bulb has a small opening on the side. The long stem is then filled with mercury except for a small quantity of air-free water at the top. The level of the mixture in the bulb stands at a predetermined line. This U tube is then inserted in a gage glass of the condenser hot well. The stem, being pressed against the inner wall of the gage glass facilitates reading, even when the nature of the water is such that the glass becomes clouded with a film of dirt or grease. Ordinarily the water level in the hot well is below the gage glass. In order to insure correct operation there should be a circulation of water through the glass and to accomplish this a small baffle is inserted at the upper connection so as to deflect a portion of the condensate through the gage glass. When the instrument is in place, the bulb fills up with water to the level of the opening in its side.

The law governing the operation of this instrument is the Dalton law of partial pressures. The operation of the instrument is based on the assumption that the mixture in the gage glass is the same as the mixture in the hot well. The vapor in the condenser exerts a pressure on the open leg, the magnitude of which is determined by the temperature in the condenser. The small quantity of water at the top of the sealed leg will also exert a vapor pressure, the magnitude of which is likewise determined by the temperature in the condenser. The vapor pressure acting on the open leg will be exactly the same as the vapor pressure acting on the mercury in the sealed leg, and these two will counterbalance. Thus, if there is only vapor pressure in the condenser, the mercury will stand at the same elevation in both legs of the U tube. If there is any air in the condenser it will exert a pressure on the open leg entirely independent of the vapor pressure, as there cannot be any air pressure on the sealed end of the U tube. This air pressure, therefore, produces an unbalancing, causing the mercury to rise in the stem until the condition of equilibrium is reached. The air pressure may then be read directly on the stem scale.

Due to the fact that furnace volumes are becoming larger and boilers are being set higher, and that the boiler gage glasses are now being located at some distance above the boiler room operating floor, a considerable demand has been created for a gage which can be located at the operating floor level.

Two or three companies are attempting to develop a periscope in order to bring the gage glass reading to a position where it can be more easily observed. The objection made so far, is that the operator must stand directly in front of the periscope, and it is questioned whether the

operators will not find it so inconvenient to walk immediately in front of each boiler in order to note the water level, that they will continue to endeavor to see the gages on the drums.

Telescopic Lenses May Solve the Problem

Periscopes, when consisting of straight mirrors, also have the disadvantage of not bringing the gage glass closer to the eye of the operator, therefore it has been suggested by some of the operators that it would be advantageous to install telescopic lenses between the two mirrors. The only periscope so far built along these lines has been unsatisfactory, due to the fact that the eye-piece on the lower end is about an inch and a half in diameter and it is necessary for the operator to look directly into it in order to determine the water level. The optical company which designed this is working on another periscope in which it hopes to correct this difficulty.

Mechanical Orsats use the principle of the hand-operated Orsat apparatus and record an actual chemical analysis. The reports from the users of these instruments show that the instrument time lag varies largely with the time required to make the individual analysis and that generally, one to four consecutive analyses are required to record the total change in the flue gas. The time lag varied in length from 2 to 10 min. for different instruments and users. The lag in these instruments does not impair the accuracy of the individual analyses.

Electric-thermal conductivity type CO_2 instruments depend upon the difference in thermal conductivity of different gases to vary the temperature and this in turn varies the resistance of one leg of a Wheatstone bridge. In this manner the thermal conductivity of the gas is compared with the thermal conductivity of air and the difference is calibrated in per cent CO_2.

The absorption-pressure type of CO_2 instrument is based on the pressure reduction in a stream of gas, from which CO_2 has been absorbed. The difference between this reduced pressure and some other constant pressure, on the same gas stream, is calibrated in per cent CO_2. These instruments have a small continuous gas stream flowing into a comparatively large absorption chamber. The reports show that the time required to clean this chamber of old gas causes the machine to have a lag of from 10 to 45 min. and the mixture of old and new gas results in an averaging effect covering the period of the time lag. These machines operate with fixed pressures or rates of flow which require water gages and levels that must be kept constant or nearly so. These reports indicate that these levels require considerable and regular attention in addition to the regular care that must be given the mechanical Orsats.

Obtaining Gas Samples

It was also endeavored to ascertain the present practice used in drawing samples for CO_2 recorders, pointing out the difficulties in obtaining a true average sample. The replies indicated that the exact reading was not of importance; but the relative relation was the desired result, therefore it was quite generally reported that samples were drawn from only one place in the breeching. A few of the companies stated that they were in the habit of using branch manifolds in order to draw their sample more uniformly across the length of the breeching. Two of the companies have made traverse readings.

In stations of a small number of units, it is a fairly simple task to use instrument readings in order to make a complete heat balance of the operation of the plant, while in plants of a large number of units and consequently a large number of instruments, the averaging of the readings becomes a task of some magnitude and the value is minimized in the process of averaging.

Larger plants can afford to pay for a great amount of supervision of the boiler and turbine room floors and with constant supervision by foremen, noting readings on indicating instruments, a sufficient analysis of conditions can be made so that the plant will not deviate far from its bogey or proper efficiency for each piece of equipment. One large company is tending more and more to the use of only indicating instruments, as it feels that the plant superintendents do not have time to go over and note daily the readings on recording types of instruments and that the responsibility of the operation must be left to the foremen or supervisors in each portion of the plant.

Recording Instruments Show Trend of Operation

More general practice seems to be, however, to use a certain number of recording instruments to show the trend of operation. The companies adopting this practice feel that even with a number of supervisors or foremen, these men are greatly aided in noting the trend of the readings from the recording chart. These charts are collected and are looked over daily by the plant engineer. Readings are then recorded on the turbine and boiler room log sheets, hourly or half hourly, from the indicating instruments, and the important information necessary to work up plant efficiency is generally placed on some kind of a daily report sheet, which is sent to the main office.

Instruments may be classified into two general groups, the first group comprises those which are used to indicate conditions to the operators. The second group are instruments which are used to indicate results which are recorded, and this group comprises only such instruments as are needed in order to make up the heat balance of the system. This heat balance, of course, is the summation of the B.t.u. used in the various pieces of apparatus.

This method of using a heat balance for checking the daily operation has been somewhat simplified by working up curves for the various boilers both banked and steaming and the number of machines running. They show the gross kilowatt-hours generated, plotted against tons of coal burned, and are plotted for six different temperatures of circulating water. This is used as the first check and if the actual results check out on the basis of this curve, which is determined from actual tests made on the apparatus, the balance is carried no further. If, however, the results deviate from these calculated results a second set of curves is used. The second set shows the machine condensate, the plant water rate and the plant coal rate plotted, with corrections which can be made for the auxiliary power and for superheat. All of these curves are also plotted with various circulating water temperatures. If the results then deviate, the trouble can be located in the boiler room, provided the plant water rate is correct, but the plant coal rate high; in the turbine room, if the plant water rate is high; in the main unit if the condensate is high, and so on. By this method the loss can then be assigned to a definite portion of the station.

One new station has adopted a much more complete

system of heat balance than any others that are at present known to be in operation. The results from this station are recorded on six separate sheets, the first sheet being devoted to the daily boiler performance. The second sheet covers the turbine and condenser performance and gives all temperatures and quantities on these pieces of apparatus, together with their corrections due to pressure, superheat and vacuum. The B.t.u. loss to the circulating water and B.t.u. transfer through the condenser are figured. The third sheet includes the heat balance of the station. In this sheet the heat losses and uses are grouped under seven different items; viz.: (1) boilers; (2) turbines; (3) the house turbine; (4) small steam-driven auxiliaries; (5) heaters; (6) motor-driven auxiliaries and (7) total. Under the total station is shown the power used in the station; the power delivered by the station; the unaccounted for loss in the station; pounds of coal per net kw-hr.; B.t.u. per net kw-hr. and station thermal efficiency.

Sheet No. 4 covers the heat balance of all heaters and the fifth and sixth sheets comprise the heat balance of the station auxiliaries showing their hours of use and overall efficiency.

Economic Operation of the Power Plant

Outline of the Tests Which Are Necessary to Run in Order to Operate a Plant Efficiently. By John D. Morgan

ONE OF THE most important factors in the economic operation of any power plant is that of the water rate, that is, the pounds of steam per kilowatt-hour or brake horsepower-hour. This factor determines to a large extent the actual cost of power generation. There is a limit to the degree or amount which the water rate can be reduced. This limit is that placed by the design of the plant, and the type of the equipment used in power generation.

Design features which limit the water rate of the station are as follows:

(1) Type of main units, such as turbines, engines, engines and low pressure turbines,
(2) Drive of auxiliary units, that is steam engine, steam turbine or electric motor,
(3) Amount of steam pressure,
(4) Amount of superheat,
(5) Amount of vacuum, and
(6) Construction of piping, pressure, drop, radiation.

Operating features which control the water rate can be grouped under the following headings; (1) elimination of all steam and water leaks, (2) maintaining the proper vacuum, (3) maintaining the maximum superheat, (4) maintaining the correct steam pressure, (5) operating the most economical units, and (6) keeping all units in proper maintenance.

The operating engineer, once a station is in operation, cannot obtain a water rate lower than that for which the station was designed. Reference to the table given herewith will show that there is a wide discrepancy between the general efficiency of power plants in different parts of the country.

TABLE I. COMPARATIVE EFFICIENCIES OF POWER PRODUCTION

State	Per cent relative efficiency base on New York	Kw-hr. per ton of fuel
New York	100	792
Pennsylvania	75	595
Illinois	75	597
Ohio	76	605
Massachusetts	95	756
Michigan	99	787
New Jersey	85	671
West Virginia	93	738
California	90	716
Indiana	46	364

From U. S. Geological Survey Division of Power Resources.

It will, of course, come as a natural conclusion that these results indicate that New York has plants which from a design standpoint are most efficient. From a careful survey, I do not think this is the case; for example, New Jersey has many plants which are the equal of New York plants for design efficiency, therefore, the proper conclusion would be that it is more a matter of operating efficiency than anything else. In an effort to obtain the most economical water rate, the first step should be that of a station water rate test on the plant as a whole.

If the plant is a small one, the proper procedure would be to weigh all the water fed to the boilers, or in a large plant, the water fed to the heaters can be calculated by a hook gage and a V-notch orifice, this method being exceedingly reliable. In addition to taking the amount of water, the output in kw-hr. should be determined for each hour's run. The height of water in the boilers and feed water heaters should be obtained at the beginning and end of the test and correction made for the difference. The calculated total water fed to the boilers (water fed to the heaters plus the weight of the exhaust steam used to heat the feed water) can be calculated by using the following formula and little error will result.

$$W_s (H - T_2) = W_w (T_2 - T_1) \text{ or} \ldots\ldots\ldots (1)$$

$$(W_t - W_w) (H - T_2) = W_w (T_2 - T_1) \ldots\ldots (2)$$

in which T_2 equals temperature of outlet water from the heater, deg. F., T_1 equals temperature of inlet water to the heater, deg. F., W_t equals total weight of the water and steam in pounds, W_w equals total weight of water in pounds, W_s equals total weight of steam in pounds, and H equals total heat of exhaust steam in B.t.u.

Tests should last for a minimum of 24 hr. and 48 hr. is better. When properly computed and rightly arranged, both in curve and chart form, the test should show the station water rate for various loads and other valuable data in reference to the station operation. When this has been done, the next step is that of obtaining the individual water rate of the main and auxiliary units. Examples are given which show the water rates of various main and auxiliary units.

Outline of Items Affecting the Water Rate

Taking up the items as they control the water rate, the matter of the elimination of all steam and water leaks should come first, as a matter of course. If it is possible at any time to shut down the plant for a period of 10 hr., a test should be made to determine the amount of steam that is necessary to take care of the leaks and radiation. This

test is generally made as follows: all the boilers are filled, that is, each boiler should have a full glass of water, then shut down all pumps and keep up the fire under the boilers to hold regular steam pressure up in the plant.

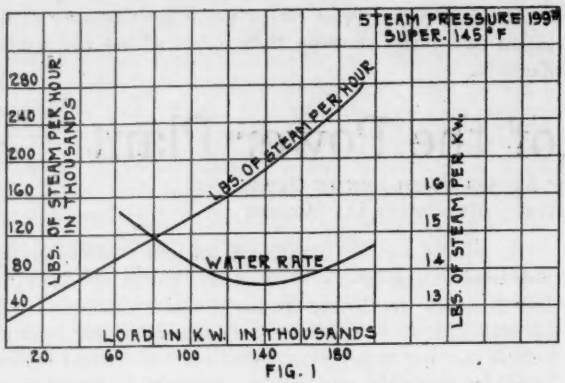
Care should be taken that the safety valves do not blow and that the blowoff valves do not leak. With steam pressure up and no units running, it is an easy matter to go over the plant and make a note of all the leaks. Records should be taken of the coal and water used each hour. While this test is not an accurate one, if it is made in a careful manner a good approximation can be made of the amount of the radiation and leaks in the plant.

If there are figures available for the total pounds of steam used per day and also the daily output in boiler horsepower or kilowatt-hours, some valuable curves can be obtained by plotting the pounds of steam against the daily output. This curve will show the water rate for varying outputs and will also show the pounds of water or steam used daily to be ready to pick up the load. This curve can also be used to determine whether the station is running at a higher efficiency than it was the year the curve was plotted. An example of such a curve is shown.

Maintenance of the proper vacuum is of utmost importance in keeping a low water rate. A curve is shown which illustrates the effect of vacuum on the water rate. To insure efficient operation of surface condensers, the following items should be looked after; (1) circulate as much water as possible through the tubes, (2) keep the tubes clean, both inside and outside, (3) keep moisture out of air removed by the dry air pump, and (4) maintain total absence of air leaks in the condenser and turbine base.

Circulating sufficient water has a marked effect on the vacuum. The lack of circulating water will be partially indicated by the temperature rise. In most cases of insufficient water, the first point of attack is that of cleaning out the impeller of the circulating water pump and cleaning the water passages to and from the pump. Also, it would be wise to take off the condenser heads and clean out all foreign matter from the circulating tube entrance.

The effect of dirty tubes, both inside and outside, is


STEAM PRESSURE 199#
SUPER. 145° F
LBS. OF STEAM PER HOUR IN THOUSANDS
LBS. OF STEAM PER KW.
LBS. OF STEAM PER HOUR
WATER RATE
LOAD IN KW. IN THOUSANDS
FIG. 1

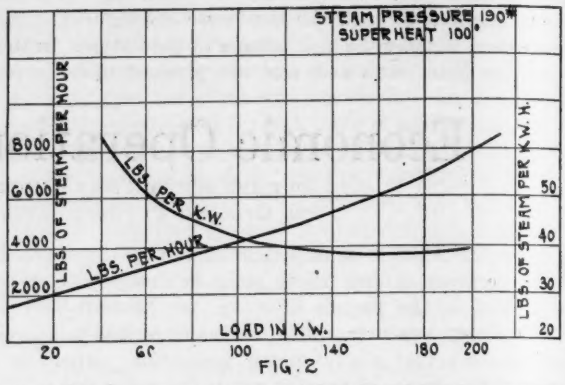


FIG. 2

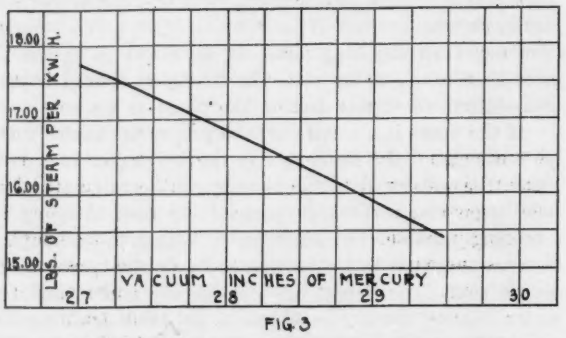


FIG. 3

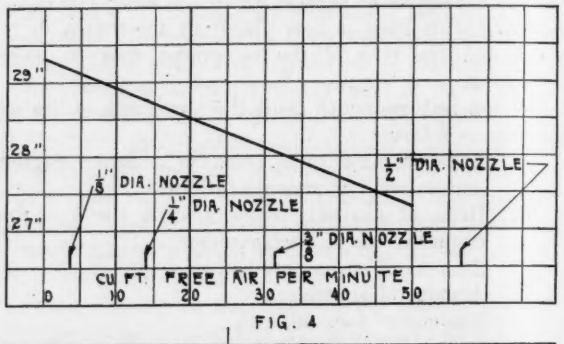


FIG. 4

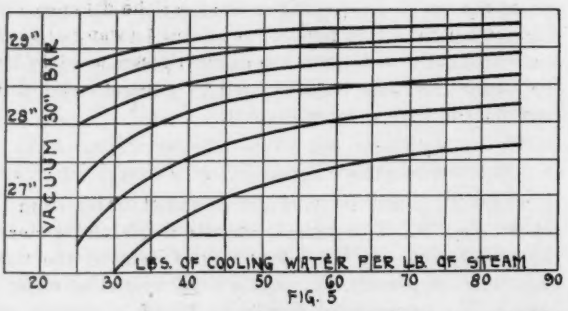


FIG. 5

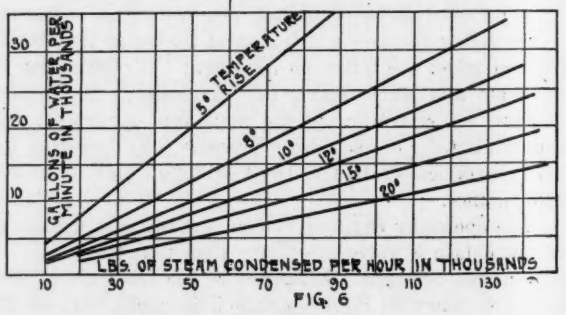


FIG. 6

CURVES LIKE THESE ARE VALUABLE IN CHECKING DAILY PERFORMANCE

Fig. 1. Water Rate Test Results on a 20,000-Kw. Turbine. Fig. 2. Results of a Water Rate Test on an Exciter Set. Fig. 3. Effect of Varying the Vacuum on a 3000-Kw. Turbo-Generator Operated at Full Load. Fig. 4. Effect of Air Leaks on the Vacuum Maintained by a Dry Air Pump. Fig. 5. Performance Curves of Jet Condensers. Fig. 6. Gallons of Circulating Water for Various Temperatures Rises. Chart Ranges from 5 Deg. Temperature Rise to a 20 Deg. Temperature Rise.

that of increasing the temperature rise and thereby decreasing the vacuum maintained. The outside of the condenser tubes should be examined and if a gum deposit is found on them, the condenser should be filled with a 4 or 5 per cent solution of soda ash and boiled with steam for several hours. This will remove all foreign matter from the tubes and will not injure them in any way, but if the

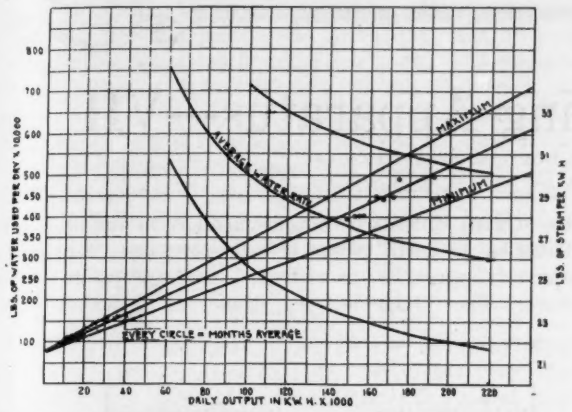


FIG. 7. POUNDS OF WATER USED PER DAY WITH A VARYING DAILY OUTPUT

solution is of greater strength than 5 per cent, some action will be noticed on the tubes. The inside of the tubes should be examined and if they are found to be dirty, they should be cleaned at once by using wire brushes or high water pressure, depending on the composition of the sediment. The cleaning of condensers should be a regular

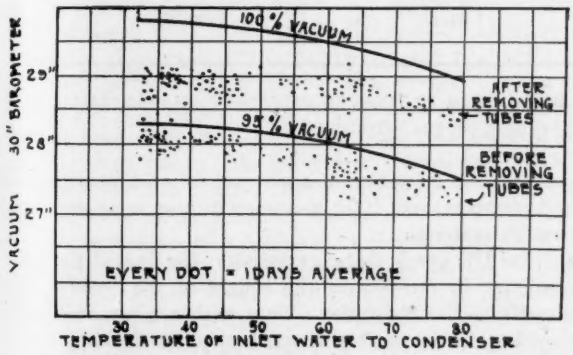


FIG. 8. EFFECT OF REMOVING TUBES FROM A CONDENSER

operating job; the temperature rise can be used as an indicator of the proper time to clean the tubes.

Changes to Condenser May Be Necessary

It is possible that the proper placing of baffles or taking out some of the tubes to form a more open steam passage will materially improve the vacuum. An example of the effects produced by taking out the tubes is shown. In some cases, the vacuum will be improved by the placing of a coiled pipe feed water heater in the exhaust pipe to the condenser. This feed water heater will give good results as a feed water heater, and at the same time assist the condenser in its operation.

Keeping moisture out of the air removed by the dry vacuum pump is of the utmost importance. If the vacuum pump is of the reciprocating type, the installation of baffles or a separator is the most practical method of keeping out the moisture; however, if the vacuum pump is of the wet type, the moisture in the air is not of prime importance.

One of the attached curves shows the effect of air leaks upon the vacuum maintained by the condenser. Location of air leaks in the condenser is a simple matter, a candle being of great assistance; or the condenser can be filled with water and if any leaks are present the water will drop out of them and the location can be marked and repaired as soon as possible.

Keeping a uniform pressure is more a matter of maintenance and regulation than of operating economy; however, the variation of 10 lb. pressure will have about 1 per cent effect on the water rate. The proper degree of superheat to carry is the maximum that the superheaters will

TABLE II. SHOWING WATER RATES OF VARIOUS STATIONS

	Type of Station	Capacity in Kw.	Aver. Yearly Water Rate. Lb.	Aver. Result at Most Eff. Point. Water Rate. Lb.	Aver. Vac.	Aver. Steam Pres.	Aver. Superheat
A	Turbine	50000	13.33	13.0	28.8	214	93
B	"	75000	18.04	16.8	28.6	198	145
C	Eng. & Tur.	24350	34.18	27.5	28.4	138	-
D	Eng. & Tur.	9600	27.17	25.4	28.0	158	-
E	Eng. & Tur.	2140	113.22	29.0	26.4	119	-
F	Engine	4800	149.90	30.0	20.	130	-
G	Engine	3525	-	30.0	-	-	-
H	Turbine	10000	20.40	19.5	28.4	198	156
I	Engine	2800	-	32.0	-	-	-
J	Turbine	1600	34.5	28.0	28.2	147	-
K	Eng. & Tur.	5950	39.61	24.2	26.	130	-
L	Eng. & Tur.	3000	-	30.0	27.5	148	-
M	Engine	1280	54.0	35.0	26.4	149	-
N	Eng. & Tur.	4200	34.35	27.5	27.5	150	37
O	Turbine	16500	16.48	17.5	28.65	194	104
P	Eng. & Tur.	6900	31.07	25.0	28.1	144	62
Q	Engine	800	-	40.0	-	100	-
R	Engine	675	-	40.0	-	-	-

give and also what the plant will stand; each 12½ deg. of superheat will change the water rate about 1 per cent. To obtain a uniform superheat, it is necessary to clean the boiler and superheater tubes at frequent intervals and to keep the boiler baffles tight in order that the superheater will receive the heated gases.

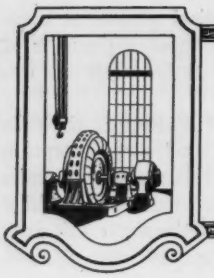
Units which have the best water rate should be the ones to receive the bulk of the load. This can be determined from the tests on the main units.

Importance of maintenance in the economic operation of the units cannot be overestimated, for faulty setting of valves, dirty or leaky admission valves, dirty buckets or blades, have a material effect on the water rate of the station. A table is given which shows the actual station water rates of several different types of power plants.

From France comes report of a new alloy of aluminum and silicon, in the proportion of 86.5 per cent Al. to 13.5 per cent Si., which has been found specially suitable for castings. It is called Alpax and was produced by Dr. Pacz of Cleveland, Ohio.

M. de Fleury says that it bears the relation to cast aluminum that cast steel does to cast iron.

As against castings of aluminum-copper alloy, whose tensile strength is 7.7 to 9.5 T. a sq. in., Alpax has a strength of 11.4 to 14.6 T. a sq. in. and elongations are 1 to 2 as against 5 to 10. Density of Alpax is 2.5 to 2.65 and shrinkage of castings about the same as for cast iron. Resistance to corrosion by sea water is reported as better than for other aluminum alloys.

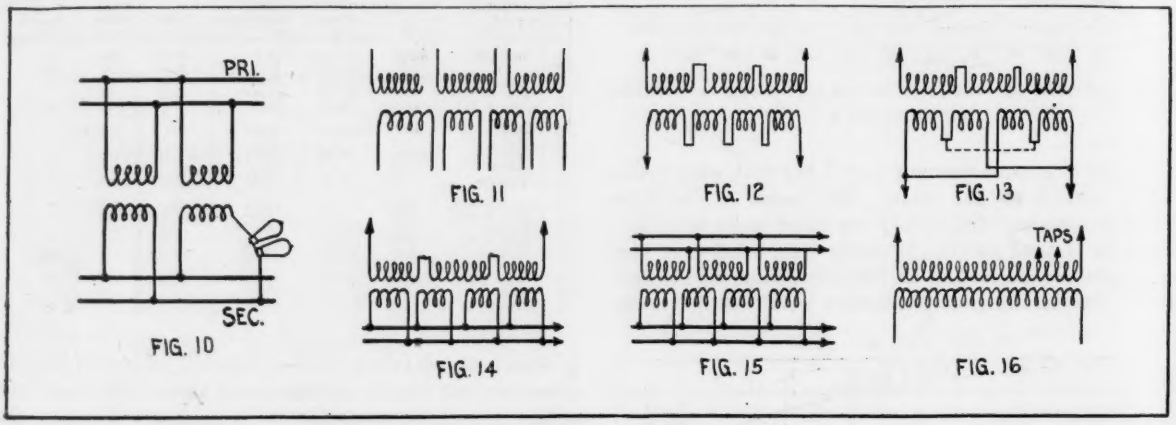


ELECTRICAL MACHINERY FOR LIGHT AND POWER

Operation of Converting Apparatus---VII

TRANSFORMERS CONTINUED. REGULATION, LOSSES INSULATION AND METHODS OF CONNECTION. BY V. E. JOHNSON.

IN THE FIRST part of this section on transformers which appeared in the February 1 issue, we took up the theory of the transformer and its action under various conditions. In this article we will discuss briefly the subject of regulation and then proceed to a consideration of losses and finally methods of connecting.



FIGS. 10-15. VARIOUS METHODS OF CONNECTING TRANSFORMER COILS TO PRODUCE DIFFERENT CHARACTERISTICS
FIG. 16. METHOD OF BRINGING TAPS OUT OF TRANSFORMERS

By regulation in a transformer is meant the ratio of the increase in voltage from full load to no load to the full load voltage. Expressed as an equation it is the following:

$$\frac{\text{No load voltage—Full load voltage}}{\text{Full load voltage}} \times 100$$

Example: Full load voltage equals 100.
No load voltage equals 110.

$$\text{Regulation equals } \frac{110\text{-}100}{100} \text{ or } \frac{10}{100} \text{ or in per cent equals 10.}$$

There are two principal losses in a transformer, the copper loss and the iron loss. The copper loss in a transformer consists of two major portions—namely eddy current and I^2R loss. The former is due to the setting up of a difference of potential in the mass of the conductors so that current will flow from one internal point to another. This current does not register on the ammeters in the external circuit, but nevertheless it takes energy. In order to reduce this loss to a minimum, the larger conductors are made from a number of small strands, insulated from one another. The insulating material between the strands consists of fibrous material in ordinary distribution or small power transformers and of mica in apparatus which has to withstand extremely severe conditions. The voltage between strands is of course low—perhaps only a fraction of a volt but in order to withstand high temperatures it is necessary to use some non-combustible material.

The I^2R loss is that occasioned by the flow of the main current. It varies with the square of the current, and directly as the resistance. Thus with a given resistance, doubling the current will quadruple the losses. At no load the I^2R loss is practically zero, as the only current flowing is that required to magnetize the iron.

IRON LOSS

The iron losses in a transformer consist of two parts, namely eddy current and hysteresis loss. The former is similar to the eddy current loss in the copper and is due to the setting up of voltage in the mass of the iron, so that current tends to flow from one part to another. In order to reduce this to a minimum, the transformer core is made from thin sheets or laminations of iron, placed in such a position as to break up the flow of current without interfering with the main flow of magnetic flux. The insulation between the laminations consists of a coating of paint or sometimes of the natural oxidation on the surface of the iron.

The second portion of the loss is due to the fact that it requires energy to reverse the magnetism of the core.

This loss varies with the flux density but is independent of the load, as is the eddy current loss. Thus the energy loss in the core of the transformer continues at all times regardless of the load conditions.

Proportioning of Losses

In designing a transformer, the matter of dividing the losses between the copper and the core is under control of the manufacturer to a large extent. Due to the fact that the iron loss goes on 24 hr. a day, regardless of whether the apparatus is doing any work, it is essential that it be kept as low as possible. On the other hand, the copper losses in distribution transformers come at the peak load period, so that it is perhaps better to sacrifice all day efficiency in favor of low copper loss. Every load condition could, theoretically, have an ideal transformer design applied to it, so that the best efficiency would be obtained under it but commercially it is necessary to base the design upon the average requirements.

Insulation

Safety and continuity of service are prime requisites, and require careful attention to the use of insulation. Inasmuch as any electrical non-conductor is also a heat insulator, it is important to regulate the material and arrangement of the dielectric so that the increase of temperature does not defeat the end sought. The ideal would be the combination of thin insulation which would permit free heat transfer, with high breakdown qualities. This explains the great use of mica for insulation.

In any transformer only a part of the primary flux links the secondary, as part of it strays away from the regular course and completes its path without cutting the secondary coils at all. As a result, there is an increase of transformer regulation above that which results from the impedance drop in the coils. To reduce leakage to a minimum it is necessary to interweave the primary and secondary coils in such a manner as to compel the flux to stay in the iron path. At no load there is little tendency for the magnetism to stray, as the iron path has less reluctance than the air, but under load conditions, the load current sets up a counter flux which tends to cause the lines of force to cross the air spaces.

The regulation of a transformer can be determined to a considerable extent by controlling the leakage. Thus when a transformer is to have a predetermined regulation in order to operate satisfactorily with other units, one of the means used to obtain this is to separate the primary and secondary coils the proper distance.

Parallel Operation of Transformers

In order for transformers to operate in parallel on primary and secondary sides they must first of all have the same ratio. If this is not true, then the unit having the higher secondary voltage will take more than its share of the load. It is not enough, however, that the ratio be the same, as this would secure satisfactory operation at no load only. In order that division of load be correct throughout the entire range of load, it is essential that the regulation be the same. If this is not true, the transformer having the smallest regulation will take the greatest share of the load, as under increasing loads, its voltage will become higher than that of the other units with which it is connected.

Figure 10 shows schematically how two transformers are connected in parallel. Before closing the final circuit between them it is necessary to know that the coils have the same polarity, as if this were not the case, a direct short circuit would result. On low voltage transformers this can be tested out by using a pair of lamps—each lamp having a rating equal to the voltage of the transformer secondaries—connected as shown. If the polarity is right the lamps will be dark, and the connection can be made. It is important in making this test to be sure that the lamps are not burned out, or dead for some other reason. Modern transformers are made with standard lead arrangements, so that it is seldom that their polarity is found to be wrong.

If the transformer secondary is too high for the practical use of lamps as outlined above, a potential transformer must be used. This must have a voltage rating equal to twice the transformer secondary—or else two transformers in series must be used. If this were not the case, and the transformers under test were of the wrong polarity, double voltage would be impressed on the test outfit.

In either of the preceding tests, an a.c. voltmeter may be substituted for the lamp. It will indicate "zero" when the polarity is right. The use of a voltmeter is preferable because it will indicate any difference of voltage due to a ratio error, while a lamp would be dark with a considerable pressure across its terminals. On the other hand, for pole top work a meter is a little difficult to handle and is apt to be damaged by rough usage.

If the transformers are connected in parallel but are separated by a considerable distance, say a block or two, any slight difference in regulation will be taken care of by the impedance of the connecting lines, so that operation will be commercially satisfactory. On the other hand, if the units to be so connected are located close together the requirement of equal regulation becomes quite important. If the transformers have large current ratings, the resistance of the interconnecting leads may affect the load division to a considerable extent, and it is important to see that the drop to the point of paralleling is the same for all of the units.

If it is found to be necessary to operate units in parallel which were not designed for such service, it can be accomplished by connecting external reactors in the circuit of the transformer having the lowest regulation. The size of these can be determined by a cut and try method but if the complete data be submitted to any transformer manufacturer, these auxiliary devices can be obtained properly designed. For temporary use, it is possible to obtain a fair division of load by using home-made resistances in series with the unit that tends to "hog the load."

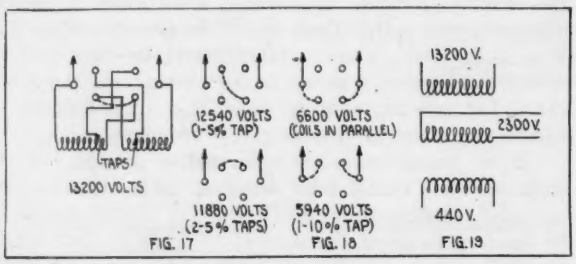
Taps and Series Parallel Coils

In order that a given transformer may be used in as many different places as possible, and so eliminate the need of a greater stock of sizes, it is customary to manufacture them with taps and with arrangements for connecting the component coils of either the primary or the secondary winding in multiple. Thus a unit with a 2400-v. two part primary winding may be connected for either 2400 or 1200 v. Similarly a 440-v. four-coil secondary can be connected for 440, 220 or 110 v. If only single coils are used, this method of making voltage changes is of course not possible.

Figure 11 shows schematically a transformer having a three coil primary which may be connected for either 2200

or 6600 v. and a four coil secondary which will give 440, 220 or 110 v. In Fig. 12 the connections show all of the coils in series, giving a ratio of 6600/440. Figure 13 shows the primary in series for 6600 and the secondary in series parallel giving 220 v. In a connection like this, applied to high voltage transformers, an equalizer as shown by the dotted line is used to connect points of equal voltage, so as to eliminate strains due to unbalance. Figure 14 shows the connections for a ratio of 6600/110. In this arrangement it is important that the secondary connecting leads have equal resistances, for if they do not, the coils will not divide the load equally between them. Figure 15 shows the primary in parallel so as to obtain a ratio of 2200/110. This same primary connection can be used with any of the previous secondary arrangements.

Various conditions make it desirable at times to maintain normal secondary voltage with low primary potential. Thus at the end of a long line the drop may amount to 10 per cent or more, and to maintain secondary voltage normal it would be necessary to reduce the number of primary turns accordingly. Thus, if the drop were 5 per



FIGS. 17 AND 18. DIAGRAM SHOWING HOW TAPS ARE BROUGHT OUT OF TRANSFORMERS
FIG. 19. SHOWING USE OF A TERTIARY WINDING

cent, normal voltage could be maintained by using a so-called "primary 5 per cent tap." If the nominal line potential were 2300 v., this tap would permit full secondary voltage with the primary reduced to 2300 less 5 per cent or 2185. For finer adjustment smaller taps are used. The standard recognized by virtually all manufacturers is either two 5 per cent, or else four 2½ per cent taps.

Taps may also be used on the secondary to take care of conditions where the voltage tends to be high. In addition to the above, it is also possible to obtain transformers with taps above normal. If the transformer can carry full load on a certain tap, this is called a full capacity or FC tap, while if the full load can not be carried the designation is "reduced capacity" or RC.

Figure 16 shows how taps are brought out on a transformer winding. Figure 17 shows one arrangement of a two coil winding with taps on each half. The dotted line shows how the connections on the terminal board would be made. In Fig. 18 the same winding is shown in parallel, and connected on the taps. In this connection it may be seen that two 5 per cent taps in series becomes one 10 per cent tap when in parallel. Similarly four 2½ per cent become two 5 per cent taps.

Distribution transformers of the smaller sizes and lower voltages are in general made without taps—and if desired these must be ordered "special." In general, for such service it is not desirable to attempt to regulate by means of changing taps, for it would be obviously impossible to change connections every time the voltage varied. On unimportant lines where the off peak voltage is immaterial, satisfactory results may be obtained by means of taps if the line drop at load requires it but ordinarily it is better practice to use feeder regulators to maintain constant line pressure. For that reason tapped transformers find their principal application on transmission line systems where the load is fairly constant, so that drop can be approximately compensated for, or in applications where the light load voltage is low enough to require tapping in order to reduce the regulation required of the feeder regulators. Thus at times a 5 per cent tap plus a 5 per cent regulator is used in place of a 10 per cent regulator—with a corresponding reduction in cost.

Tertiary Windings

Recently transformers have been designed for use on special applications with three separate windings—known respectively as primary, secondary, and tertiary. Figure 19 shows schematically the connections of such a transformer having voltages of 13,200, 2300 and 440. Power can be supplied at any one voltage and taken off at the other two simultaneously. Or power can be supplied on two windings simultaneously and taken off on the other one. This makes a flexible arrangement and is desirable where three voltages must be interconnected. For example, a certain industrial plant might have 440-v. motors, generate power at 2300 and buy power at 13,200 v.

Physically, a three winding transformer as above is about 50 per cent larger than the same unit without the tertiary winding. This is evident from the fact that the third coil must be able to carry full load; however, closer application to the conditions of any particular installation sometimes reduces the size of one of the windings, or of two of them. Considerable flexibility is possible in this respect. For example, with a primary coil capable of carrying 1000 kv.a. the secondary and tertiary could each be 1000 kv.a. so that full load could be transmitted in any direction. Or, the primary could be made 1000 kv.a. while the secondary and tertiary windings were 750 and 250 kv.a. respectively. The combinations are endless.

The load imposed on three windings must be carefully watched, as it would be easy to overload the unit if readings were omitted on any one of the windings. The total load must not exceed the rating of the transformer.

When high voltage transformers are designed with three windings, it is sometimes quite difficult to install the connecting loads so as to maintain the required clearance. For that reason each particular problem must be considered not only in the light of the desired voltages and load capacities but also with reference to space limitations.

Valve area of a pump, which is generally expressed as a percentage of the water piston area, is the ratio of the total area of the effective suction or discharge valves on one stroke of the piston to the area of the water piston. The valve area is generally taken as the area through the valve seat on the assumption that the valve will lift a sufficient amount, so that the area measured at the periphery of the valve will be equivalent to the area of the opening in the valve seat. In a direct-acting pump, there is generally the same number of suction valves and discharge valves; hence, valve area may refer to either suction or discharge area.

Insulating Oils for Circuit Breakers

ONE SINGLE DROP OF WATER IN TWO GAL. OF OIL WILL LOWER THE DIELECTRIC STRENGTH BY 4000 V. BY DEAN HARVEY

IN THE OPERATION of oil circuit breakers the function of the oil is to serve as a fluid insulator of high dielectric strength, which will quench the arc formed between the stationary and movable contacts when the circuit breaker opens under the most severe overload conditions. The intensity of the arc formed when opening contacts under load depends upon the amount of current, the voltage and the rate of separation of the contacts. The heat of the arc vaporizes a small portion of the arcing contacts and some of the oil immediately surrounding the arc zone, with the formation of gas and particles of carbon and copper. The amount of these products formed depends upon the energy interrupted. The gas which is formed is immediately displaced by the oil which surrounds the contacts, and the arc is quenched at a succeeding zero value of the current wave. The rapidity with which the arc is quenched depends upon the time required to displace the gas by oil.

Each time the circuit breaker opens the circuit some carbon is formed, even though only the charging current

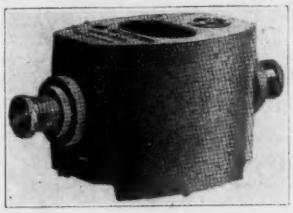


FIG. 1. DIELECTRIC TEST CUP

of the line is being interrupted. Hence repeated operations will in time make it necessary for the oil to be purified. When the oil is free from water the particles of carbon will gradually fall to the bottom of the tank. Carbon and water have, however, an affinity for each other and when both are present they unite, remaining to a large extent in suspension in the oil. The electrostatic field around the contacts tends to draw the carbon towards them and deposit it upon the insulation near by, reducing the resistance over the surface of the insulation.

In order to provide adequate insulation, it is necessary for the oil to have high dielectric strength. The standard test for dielectric strength consists in applying voltage between terminals immersed in the oil in a standard test cup, such as shown in Fig. 1. The electrodes are discs one-inch in diameter spaced 0.1 inch apart and are immersed at least 0.79 inch (2 cm.) below the surface of the oil. The test voltage is increased at the rate of approximately three thousand volts per second, until breakdown ensues. Five breakdowns are made on each filling of oil in the test cup, and the average is taken as the dielectric strength of the oil.

Oil in good condition should have a dielectric strength of at least 22,000 v. The dielectric strength is greatly affected by even minute quantities of water, as shown in Fig. 2. Particles of carbon, dust or other foreign materials in suspension also reduce the dielectric strength.

Oil having a dielectric strength of 22,000 v. contains about seven parts of water to one million parts of oil by volume, or one drop of water to about two gallons of oil. The addition of one more drop of water, uniformly distributed in this quantity of oil, will lower the dielectric strength to about 18,000 v. at which value the oil should be dehydrated.

VISCOSITY

The viscosity is measured by determining the time required for a definite quantity of oil at a certain temperature to flow from a standard vessel through an orifice of specified dimensions. The apparatus in general use for

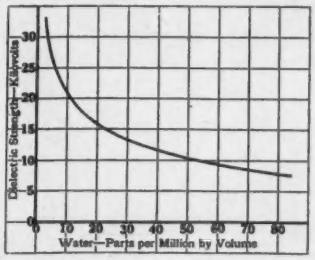


FIG. 2. RELATION BETWEEN DIELECTRIC STRENGTH AND AMOUNT OF WATER IN INSULATING OIL

determining the viscosity of oils is the Saybolt universal standard viscosimeter. This apparatus consists of an oil tube, surrounded by a bath of oil or water, by means of which the sample of oil is maintained at the desired temperature in the oil tube. The outlet tube at the lower end of the oil tube must conform accurately to the standard dimensions. The time in seconds for sixty cubic centimeters of oil to flow out of the outlet tube is the viscosity of the oil at the temperature at which the test is made. Insulating oils are usually tested at a temperature of 100 deg. F.

It is desirable to have the viscosity of the oil as low as practicable without interfering with the other essential properties, as the fluidity and the specific gravity of an oil largely determine the ability of the oil to throw down both carbon and water to the bottom of the tank.

NEUTRALIZATION

Oil should be free from mineral acid, the source of which is the sulphuric acid used in refining. This is completely removed by the subsequent treatment in refining. A small amount of organic acidity will always be present but is not objectionable as it does not injure either the metal or insulation, nor does it lower the dielectric strength. High organic acidity interferes with the demulsibility of the oil.

DEMULSIBILITY

The oil should be so thoroughly refined that it will have a high degree of demulsibility, that is, the property of quickly separating out any water present. This is a particularly desirable property for an oil to be used in a circuit breaker as, on account of the service conditions, this apparatus cannot be tightly closed like a transformer, and some moisture is likely to be introduced into the oil.

In the case of circuit breakers installed outdoors, it is necessary to see that the oil does not freeze when subjected

to the lowest temperature to which the circuit breaker will be exposed. This test is made by placing the oil in a standard size of test jar containing a thermometer and inserting the test jar in a cooling bath. At each five degrees thermometer reading, the test jar is removed and tilted to ascertain whether the oil remains liquid and then is replaced in the cooling bath. The lowest reading of the test thermometer at which the oil shows any movement when the test jar is held horizontally for five seconds is taken as the pour point.

Sampling

In obtaining samples of oil for dielectric tests it is necessary to take the greatest care to avoid contamination, as otherwise the test is likely to be misleading. The procedure outlined below should be closely followed in order to insure accurate results.

The sample bottle should have at least 8 ounces capacity. The clean, dry bottle should be thoroughly

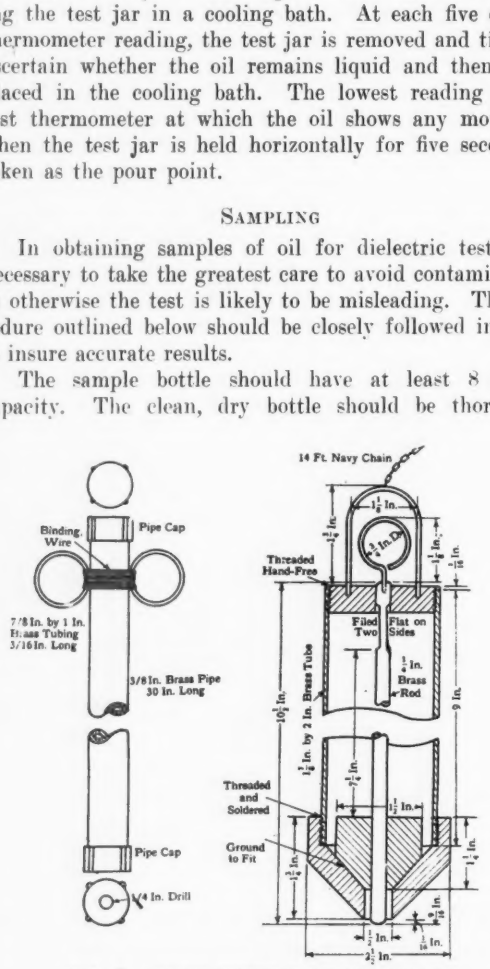


FIG. 3. HAND THIEF FOR SAMPLING OIL
FIG. 4. TRAP THIEF FOR SAMPLING OIL

rinsed with benzine or gasoline which has previously withstood a dielectric test of 25 kv. by the method described below, and should be allowed to drain.

Sampling thief, when not in use, should be kept in a hot dry cabinet or compartment at a temperature not less than 100 deg. F., and should be stored in a vertical position in a rack having a suitable drainage receptable at the base. Two types of thief are illustrated in Fig. 3 and 4.

Samples should not be drawn from containers indoors until the oil is at least as warm as the surrounding air. Insulating oils are not hygroscopic, but cold oil may condense enough moisture on the surface from a humid atmosphere to affect its insulating properties seriously. Sampling oil from containers out of doors is undesirable, due to the possibility of condensation of moisture, and should be avoided whenever possible.

In taking a sample with the thief shown in Fig. 4, the top hole of the thief is closed with the thumb, the thief thrust to the bottom of the container, and the thumb removed. When the thief is filled, the thumb is replaced, the thief quickly withdrawn and the contents allowed to flow into the sampling receptacle. Neither the lower hole nor the oil should be touched by the free hand. The thief must be suitable for reaching the bottom of the container and the sample should be taken with the thief about ⅛ inch from the bottom.

When the sampling receptacle is filled it should be closed quickly and the bung replaced in the container and tightened. The sampling receptacle shall be taken to the testing laboratory as quickly as feasible, and carefully protected from moisture during transit.

Sample

At least one-half pint of oil should be taken as a sample. One sample may be taken from each drum or, if desired, a composite sample may be made from oil from five drums, provided all of the drums are air-tight. When first loosening the bung a hissing sound should be heard, indicating that the drum has been air-tight. If the test of a composite sample is not satisfactory, a sample from each of the drums represented should be tested. When drums have been stored exposed to the weather, a sample from each drum should be tested.

Sampling From Circuit Breakers

When taking samples of oil from circuit breakers where a thief cannot be used, the procedure outlined above should be followed as far as practicable. In addition, care should be taken to procure a sample which fairly represents the oil at the bottom of the tank. Sufficient oil should be drawn off before the sample is taken to insure that the sample will not be that which was stored in the sampling pipe.

The same care should be taken in making the dielectric test as in sampling the oil, to avoid contamination of the sample. It is important that the method outlined below be followed in every detail in order to insure reliable results.

The sample should be tested between polished brass circular disc electrodes one inch in diameter and having a square edge. The electrodes are placed with their axes horizontal and coincident, and with a gap of 0.1 inch between their adjacent faces.

Other forms of test gaps now in use are: (1) metal discs 0.5 inch in diameter spaced 0.2 inch apart with their axes horizontal, and (2) spheres 0.5 in diameter spaced 0.15 inch apart with the axis of the gap vertical. If the values of dielectric strength observed with gaps of these two types are multiplied by the factors 0.55 and 0.50 respectively, the results will give the dielectric strength of the oil in the standard gap of one inch discs spaced 0.1 in. apart.

The electrodes and the containing vessel are wiped clean and thoroughly rinsed with oil-free, dry gasoline until they are entirely free from fibres. The test cup is filled with gasoline and voltage applied with uniform increase at the rate of approximately 3000 volts (r.m.s.) per second until breakdown occurs. If the dielectric strength is at least 25 kv. the cup is in suitable condition for testing the oil. If a lower test value is obtained, the cup should again be cleaned with gasoline and the test repeated.

The temperature of the gap and of the oil samples should be between 68 and 86 deg. F. Testing at lower temperatures is likely to produce variable results which may be misleading. The gap is filled with oil, to a height of not less than 0.79 in. (20mm.) above the top of the discs. Voltage is then applied and increased uniformly at a rate of approximately 3000 v. (r.m.s.) per second until

breakdown occurs, as indicated by a continuous discharge across the gap. (Occasional momentary discharges which do not result in a permanent arc may occur; these should be disregarded.)

Provision should be made for opening the primary circuit as promptly as possible after breakdown has occurred, in order to prevent unnecessary carbonization of the oil. After each puncture the testing vessel should be jarred to loosen particles of carbon adhering to the electrodes and to gently agitate the oil, but not with sufficient violence to introduce air bubbles.

When used oil is being tested, the sample should be agitated so as to provide a representative sample, using a swirling motion to avoid introducing air. Otherwise, impurities in the oil may settle to the bottom and the test may be misleading.

Five breakdowns should be made on each filing. The report should include the volts (r.m.s. value) at each "shot," the average of the five, and the approximate temperature of the oil at time of the test.

Precautions must be taken to insure the absolute dryness and cleanliness of the apparatus before filling it with oil, and to prevent the entrance of water or other foreign material during the transfer of the oil to the apparatus. When carbonized oil is removed from a circuit breaker in service, thoroughly clean all carbon from the interior of the circuit breaker. This may be done by flushing with gasoline, followed by clean insulating oil and wiping with clean dry cotton cloths. Cotton waste is undesirable on account of the lint which may be introduced into the oil.

When a drum of cold oil is brought into a warm room it will sweat, and the moisture on the surface of the drum is very likely to mix with the oil flowing from the drum. It is therefore important that the drum be allowed to stand in the room for a sufficient length of time to reach room temperature before breaking the seal on the drum. This may require 8 hr., or longer under extreme temperature conditions.

When the circuit breaker is outdoors and warm oil is introduced into a cold tank, the warm air above the oil is likely to cause condensation of moisture on the sides of the tank. The temperature of the oil should therefore not be more than about 18 deg. above, and should not be below the temperature of the tank, before transferring it to the circuit breaker. The oil storage should be so located that oil will be immediately available at the temperature of the apparatus. If it is desired to transfer the oil directly from the purifying outfit to the circuit breaker tank, the pipe line may be made long enough to allow the oil to cool to the proper temperature. It is very desirable that the preparation and filling with oil of outdoor circuit breakers be done on a clear, dry day; if this is not practicable adequate protection against moisture should be provided. All vessels used for transferring the oil should be carefully inspected to see that they are absolutely dry and clean.

Although the drums and tank cars are thoroughly washed and dried at the refinery before filling, some scale may be loosened from the inside in transit. Oil which has not been filtered should be strained through two or more thicknesses of muslin or other closely woven cotton cloth which has been thoroughly washed and dried to remove the sizing. The straining cloths should be renewed as often as necessary. It may be found convenient to stretch the cloth across a large funnel. Metal hose and not rubber hose should be used, as the oil may be contaminated by the sulphur in the rubber.

The oil should be sampled and tested before being transferred to the apparatus. The oil in all apparatus should be sampled and tested before the apparatus is put into service.

Oil which has been used in lightning arresters contains water and harmful chemical impurities and must not be used in circuit breakers.

The principal causes of deterioration of the oil in circuit breakers in service are water and carbonization of the oil caused by the opening of the circuit breakers under load. Insulating oils are not hygroscopic, but they may receive water through condensation on the surface of the oil or on the inside of the tank due to the introduction of moist air. The carbon reduces the dielectric strength of the oil, lowers the surface resistance of the insulation and tends to hold in suspension in the oil any water present. These effects are especially to be guarded against in cold weather as, on account of the greater viscosity of the oil at low temperatures, carbon is not as readily dispersed through the oil.

Many users of oil circuit breakers have not given them the attention they should receive, especially as regards the quality of oil, but are now becoming convinced of the necessity for periodic inspection and testing of the oil, and of purifying it when necessary to maintain it in good condition. When this practice is followed, the best results with the apparatus and the greatest economy in the use of the oil are obtained.

The frequency of inspection and testing depends upon the service to which the circuit breakers are subjected. These which open the circuit frequently under heavy loads require much more frequent inspection and purification of the oil than those subjected to lighter duty.

It is recommended that a schedule for inspection be prepared, based upon the operating conditions. The station log on the operation of the circuit breakers, together with the record of dielectric tests of the oil, will furnish the data from which the frequency of inspection and test may be determined. The period of time between successive inspections should never be longer than six months.—Electric Journal.

Side Lights on Power Plant Lighting

By H. Carroll

SOME MONTHS ago the writer noted with interest in Power Plant Engineering an article* on the subject of illumination in the control room of electric power plants. This article was of considerable interest and contained much valuable information. There are, however, vastly more power plants where lighting is called upon to meet more severe conditions and where conditions are more difficult than in the electrical control room of the large plants.

The visibility of electrical instruments can be much increased by using white numerals upon a black background instead of following the orthodox practice of having figures and words in black upon a white background.

The importance of keeping flexible leads and portable lamps in first-class condition cannot be over emphasized. many men have lost their lives by electric shock due to

*"Unusual Phases of Power House Lighting" by A. F. Loewe. September 1, 1924 issue.

defective insulation, grounds, etc. While the portable lamp is often necessary, is almost indispensable for examining interiors of boilers, etc., someone should be delegated to the task of seeing that they are fit for use. Boilers, stokers, wet ashes, etc. all constitute a low-resistance ground and the effect of potential may be exceptionally severe. The fact that the workman may be hot and the hands covered with perspiration decreases the surface and contact resistance of the human body, so increasing the flow of current for a given applied electromotive force.

The majority of boiler rooms are inadequately illuminated. Corrosion may exist unsuspected when the illumination is poor. Conditions are tolerated in the dark boiler room that would never be allowed to exist if the lighting were adequate.

The majority of power plant accidents result from stumbling and falling over objects, which at once proves insufficient illumination is the major cause of such accidents.

Expensive instruments are frequently found in dark and out of the way places where the lighting is insufficient for them to be used properly. In fact, it is frequently found that these instruments are out of service, filled with soot and so corroded, as to be worthless, thus failing to bring any returns on the investment for the sole reason they are neglected because located where they cannot be readily seen.

Gage glasses, instruments and similar apparatus should be properly illuminated so that the light is cast upon what the fireman wishes to see instead of the lighting unit casting a shadow which hides the equipment or causes a glare which hampers the fireman's work or injures his sight.

Boiler room lighting should consist of two distinct parts. One consists of a general lighting system which suffices for safety and comfort. The other lighting system should supplement this and should consist of individual lighting units strategically located to illuminate instruments, special equipment, etc.

Facilities should also be available for obtaining additional lighting safely and without delay for inspecting the interior of boilers.

Editor's Note: In connection with Mr. Carroll's article readers will be interested in knowing that A. F. Loewe will present a comprehensive article on lighting in the boiler and turbine room, in an early issue of Power Plant Engineering.

Practical Applications of Hydraulic Principles---II

FUNDAMENTAL LAWS EXPLAINED IN PART I APPLIED TO VENTURI METER, SHOWING HOW FORMULA IS DERIVED. SOLUTION OF PRACTICAL PROBLEM. BY R. T. LIVINGSTON

IN THE first part of this article the two fundamental laws of pipe flow were discussed. Before passing to a consideration of other laws and theorems we will do a problem to illustrate the application of these laws.

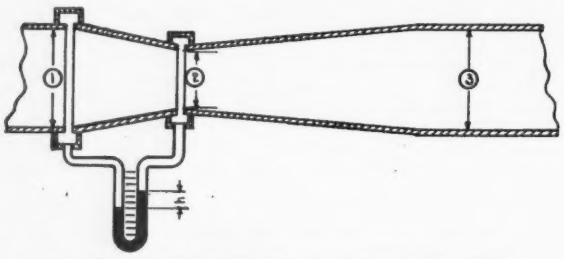


FIG. 1. VENTURI METER, SHOWING MANOMETER CONNECTIONS

One of the commonest forms of water measurement devices is the Venturi meter, invented by Clement Herschel and illustrated in Fig. 1. This meter consists essentially of two sections: the first, of gradually decreasing area, where the water is accelerated and the velocity head increased at the expense of the static head; the second, of gradually increasing area where the water is retarded and the velocity head reconverted to static head with the minimum loss. Two static pressure rings are attached, one of normal area at the entrance, and the other at the section of least area and hence greatest velocity. If a manometer is connected across these two rings a reading of difference of static pressure will be obtained and this difference will be a measure of the quantity flowing.

Let us endeavor to show that this is true and to derive the formula for the Venturi meter from the theorem of continuity of flow and Bernouilli's theorem.

Figure 1 illustrates a Venturi meter. Let us now write Bernouilli's theorem between points 1 and 2.

$$H = P_1 + (V_1^2 \div 2g) + Z_1 = P_2 + (V_2^2 \div 2g) + Z_2$$

Now we will assume that the Venturi is horizontal and in consequence we need not take the elevational heads into account. Then this equation becomes, collecting the static pressures on one side and the velocity heads on the other:

$$P_1 - P_2 = (V_2^2 - V_1^2) \div 2g = h$$

Here "h" is the difference of reading of static pressure gages placed at points 1 and 2, or the manometer reading as installed in Fig. 1.

Now we wish to measure the velocty at some point and in this expression the velocities at two different points occur. We shall, therefore, express the velocity at one point in terms of the velocity at the other and the ratio of the areas, by the theorem of continuity of flow.

$$V_1 = V_2 \times (A_2 \div A_1)$$

$$\text{hence } h = [\, V_2^2\, (1 - [A_2^2 \div A_1^2])\,] \div 2g$$

Solving for the velocity, the term we wish to measure, we then have:

$$V_2 = \sqrt{2gh} \div \sqrt{[1 - (A_2^2 \div A_1^2)]}$$

By the same theorem of continuity of flow we know that the quantity is equal to the velocity multiplied by the area and introducing a factor or "coefficient" to take care of any losses in the meter we have the following expression:

$$Q = A_2 \times K \times \sqrt{2gh} \div [1 - (A_2^2 \div A_1^2)]$$

The factor K in a well-designed Venturi meter is close to unity. The lower part of the expression is usually termed the "velocity of approach factor" and is a constant for any given meter. Figure 2 gives the value of this factor for different ratios of $A_2 \div A_1$ and if that factor, K_{va}, is used, the equation may then be written:

$$Q = A_2 \times K \times K_{va} \times \sqrt{2gh}$$

As this last term may be obtained from the curve given in the previous section of this article all that is needed is to multiply the various terms together to secure the discharge of any Venturi meter.

In similar manner, the equations for nozzles and orifices can be derived and it is hoped that such readers as are interested will attempt these derivations.

In order to give a little practice in the use of these laws it is suggested that the following problem be solved. The solution will be presented in an early issue.

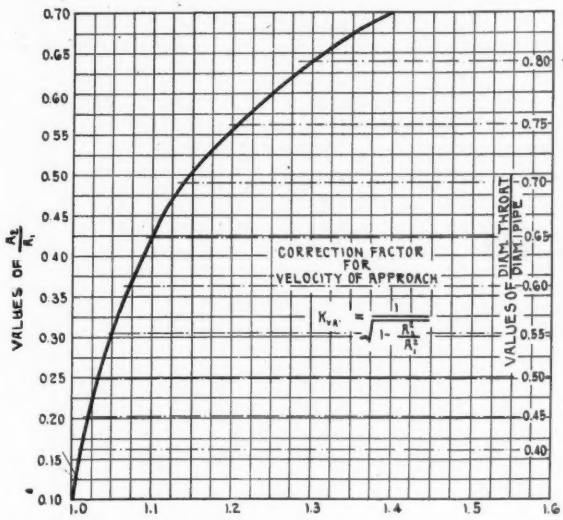

VALUES OF $\frac{A_2}{A_1}$
CORRECTION FACTOR FOR VELOCITY OF APPROACH
$K_{va} = \frac{1}{\sqrt{1-\frac{A_2^2}{A_1^2}}}$
VALUES OF DIAM. THROAT / DIAM. PIPE

FIG. 2. VALUES OF FACTOR FOR VELOCITY OF APPROACH

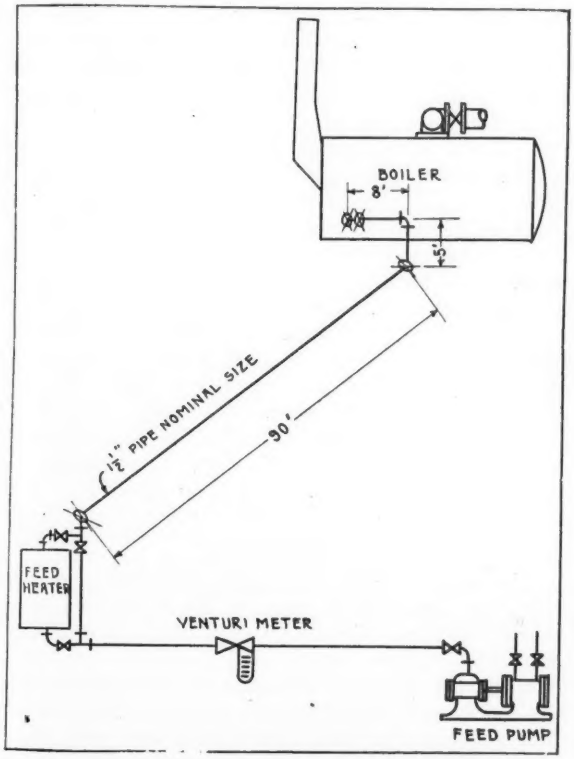


FIG. 3. CONNECTIONS FOR BOILER, HEATER AND PUMP TO ILLUSTRATE PROBLEM

A boiler feed-pump is connected to a boiler in accordance with the accompanying sketch, Fig. 3. The boiler requires 100 g.p.m. and operates at 180 lb. per sq. in. pressure. There is a Venturi meter on the cold side of a closed feed water heater and the water is at standard conditions when it enters the heater. It is desired to know what pressure will have to be maintained at the pump discharge and also what will be the reading across the Venturi meter.

It will be necessary to make a few assumptions. Assume that the pressure at the boiler check-valve must be 10 per cent above boiler pressure. There will be a loss of head through the feed-water heater and through the feed-control valves; assume that it is 20 ft. in each case. All other constants can be assumed from the sketch.

Solution of Problem

Steps

1. 100 G.P.M. $= \frac{100 \times 231}{1728 \times 60} = 0.2225$ cu. ft. per sec.
2. Area 1½ pipe inside = 2.04 sq. in. = 0.01395 sq. ft.
3. 0.2225/0.01395 = 16 ft. per sec. = velocity in pipe
4. Venturi dimensions = 1.61 in./1.25 in.
5. Venturi areas = 2.04 sq. in./1.227 sq. in.
6. K_{va} (from chart) = 1.250
7. Reading of Venturi meter = 7.05 ft. of water.
8. Head required at boiler 180 lb. per sq. in. × 110 per cent × 2.31 = 457 ft.
9. Loss through heater = 20 ft.
10. Loss through valves = 20 ft.
11. Feet of pipe = 180
    7 Ells = 210
    1 Tee = 40

    $430 \times 0.05 = 21.5$ ft.

Wherein 0.05 equals the loss per foot, from chart, page 190, Feb. 1 issue.

Total head required at pump = 518.5 ft.
Converted to lb. per sq. in. = 222 lb. per sq. in.

Operating Centrifugal Pumps

THE PUMP must always be primed before starting, otherwise the interior parts which depend upon the water for lubrication, will be injured. Never run a centrifugal pump empty. As soon as case is primed by any method the pump should be started with discharge valve closed and brought up to speed. Then open the gate valve slowly until the desired quantity of water is obtained. Failure of pressure to increase with the speed indicates air in the pump casing. In this case, stop the pump and prime again.

As long as the water and consequently the case do not heat up excessively, due to friction produced by the rotation of the impeller, the centrifugal pump may be operated with a closed discharge valve. In contrast with displacement pumps, no bypasses are required, nor can the pump or the pipe system be damaged as the shut-off pressure is only 10 to 15 per cent greater than the pressure at full capacity.

Always run the pump in the direction of the arrow cast on the case. Centrifugal pumps can be run only in one direction.

During the operation, stuffing boxes and bearings must be inspected occasionally. The centrifugal pump does not require any other attention.

If the pump is to be idle for long periods, it should be taken apart, cleaned and oiled. This prevents parts rusting together and preserves their good condition.

Heating and Ventilating a Steam Power Station*

DESCRIPTION OF SYSTEM USED AT WEYMOUTH SHOWS TREND IN HEATING AND VENTILATING SYSTEM DESIGN. BY D. S. BOYDEN AND A. B. WILLIAMS

UNTIL QUITE recently, the question of heating and ventilation of steam power stations has received little consideration. Heat radiation from power producing equipment as a rule was sufficient to take care of the heating requirements in the average station and no special heating equipment was installed. The modern power station, however, does present heating and ventilating problems which require careful study. The formulation of the requirements at the new Weymouth Power Station of the Edison Electric Illuminating Co. of Boston, and a study of the methods used to fulfill them, forms the subject of this paper.

The Weymouth Station is of the most modern design and is intended for an ultimate development of from 300,000 to 400,000 kw. The initial installation has a capacity of 67,000 kw. consisting of two 32,000-kw. main turbo-generators and one 3000 kw. ultra-high pressure turbo-generator. The boiler equipment at present consists of three 2000-hp. boilers for 350 lb. steam pressure and one 1600-hp. boiler for 1200 lb. steam pressure.

In a modern power station of this type, the heat available for heating the building by radiation from the power equipment is comparatively small in quantity. It is necessary, therefore, to supplement this heat by artificial heating during the severe winter weather. In summer it is necessary to provide ventilation to maintain the plant at a comfortable point; however, the heat to be carried away is so moderate in quantity that by careful design it is possible to secure satisfactory ventilation by natural circulation except in certain special cases.

STEAM SUPPLY

The heating system is based on steam supply at 10 lb. pressure. The entire plant including outbuildings is heated from a central point with a distributing system of supply and return lines. Before deciding on the source of steam supply a number of plans were considered. The one chosen is the utilization of the exhaust from a small turbine-driven direct-current generator. This unit is largely supplementary to other equipment and can be operated at any load desired so that steam exhausted from its driving turbine can be made to fulfill exactly the heating requirements of the plant. To avoid a special attendant for the operation of this unit it was decided to adopt the novel plan of placing the control of the supply to the heating system and of the turbo-generator on the main switchboard. This was accomplished by installing an electrical remote indicating gage showing the pressure on the heating supply receiver with its remote indicator located on the main switchboard. Near this remote indicator is the control for the turbo-generator supplying the necessary steam. It is necessary for the operator merely to observe the steam pressure and keep it to the predetermined limits by adjusting the load on the turbo-generator. When the operator notes a decrease in steam pressure he offsets it by an increase in load giving more exhaust steam and vice versa.

The output of this turbo-generator is utilized for station auxiliary purposes and has sufficient value to pay a considerable yearly premium. In considering this installation it should be borne in mind that practically no attendance is required nor any special apparatus as the turbo-generator used forms part of the regular station equipment.

In order to supplement the steam supply just described a special reducing valve operating on steam at full boiler pressure is installed, discharging directly into the heating system receiver. The initial heating requirements indicate a maximum demand for 10,000 lb. of steam per hour. To supply this quantity of steam reduced from 350 lb. pressure to 10 lb. pressure and properly desuperheated together with the necessary nicety of regulation required a reducing valve of unusually excellent characteristics. The valve used consists of a 3-in. extra heavy steel body angle valve. The seat has been replaced by a carefully designed Monel nozzle of the stream line type. The disc of the valve has been replaced by a combination needle valve and disc. This needle valve in combination with the nozzle provides steam throttling passages of stream line contour, at practically all capacities from zero to maximum flow. A further refinement is that the effective throat of the nozzle is maintained well away from the disc seat so that the valve can operate under severe conditions without erosion due to "wiredrawing." The valve is operated by a motor and reduction gear. This provides an extremely powerful positive motion and effectively prevents any possibility of chattering. The motor is controlled by a reversing relay panel operated by a pressure gage connected to the receiver tank. The gage and control are adjusted so that the valve begins to open when the pressure in the tank drops to 7 lb. If the pressure continues to drop the valve continues to open in proportion, until it is open wide at 5 lb. The operator at the switchboard who controls the quantity of exhaust steam, should maintain the pressure in the exhaust header between 7 and 10 lb. The reducing valve, therefore, functions when there is not sufficient steam coming from the exhaust system to maintain a minimum of 7 lb. in the receiver. The receiver tank contains a number of water nozzles which spray the steam as it passes through the tank, thus providing sufficient evaporating effect to destroy the high superheat which would otherwise be present. The low pressure system is protected from possible excessive pressure by suitable safety or back pressure valves.

RETURN SYSTEM

The heating system is laid out on the two-pipe principle, with thermostatic traps on the return end of all radiating fixtures. The condensate is conserved in all cases and returned to a concrete heating return tank located alongside the distilled water tank in the power station. The water in the heating return tank is returned to the main power station feed system by a horizontal motor-driven centrifugal pump operating under float control. Should this pump be out of service for any reason, the water overflows to the station distilled water tank where it is returned to the main feed system by the distilled water pumps, in accordance with make-up requirements of the boilers.

In the turbine room the heat generated by the power equipment is in general sufficient to maintain a satisfac-

*Abstract of a paper presented at the convention of the American Society of Heating and Ventilating Engineers, at Boston, Jan. 28-30, 1925.

tory temperature. The large areas of glass in the full height windows require special treatment as they would otherwise produce undesirable cold-air currents. To counteract the loss of heat from these windows direct radiation is installed in wall recess under the windows. The warm air from this radiation is discharged through grilles immediately below the glass. Sufficient radiation is provided to temper the air completely in most severe weather.

A problem characteristic of power station work is the condensation of moisture on the underside of the roof. At the Weymouth Power Station this has been cared for by placing insulating material in the roof slab so as to prevent heat loss and chilling of the underside of the roof with the consequential condensing of the water bearing vapors.

At the entrance of the power station the turbine room is extended to form an office building. Here are located the executive offices and rooms for clerical work together with laboratories, and in the future dining rooms and sleeping quarters. The heating system in the office building follows the usual design for this class of work. The heating is of the direct radiation type, largely single column supported by brackets on the walls and without legs. No attempt is made for special ventilation other than the natural ventilation found in a building of this class.

Boiler Room

In the boiler house the windows have been treated with direct radiation as in the turbine house except that the radiation here is not concealed. The ash basement in some plants is a source of extreme cold if the forced draft fans draw their air from this space. At Weymouth, the fans are located in a single long fan room partitioned off from the rest of the basement. The air inlets to this room are through louvres in the outside wall. In this way the low temperature and high velocity air currents are confined. In the future it is proposed to install ventilating fans near the top of the boiler house which will draw the warm air from this point and force it through ducts into the forced draft fan room. In this way the tendency for warm air to collect in the upper part of the boiler room will be eliminated, and the fan room will be tempered and the warm air made available for combustion purposes. In the boiler house the absence of all floors above the operating level allows excellent air circulation. The operating aisle is kept clear of galleries and is opened directly to the skylight in the roof over the boiler house. Louvres in the side of this skylight provides the necessary ventilation. This is augmented by swinging sash in the boiler house.

Smoke uptakes and flues together with cinder catchers, economizers, and induced draft fans are carefully insulated so that radiation is reduced to a minimum and the temperatures in the upper part of the boiler house will probably not be uncomfortably high at any time.

Auxiliary Bay

The auxiliary bay has certain spaces such as battery room and auxiliary switch room in which direct radiation is not desirable for electrical safety reasons. These spaces, however, require both heating and ventilation. To accomplish this, a supply fan with a bank of vento heaters and a system of supply and exhaust ducts have been installed. In this way the temperatures can be maintained and ventilation provided in both summer and winter. The obnoxious fumes from sulphuric acid in the batteries make the ventilation requirements of the battery room severe, and a special exhaust fan has therefore been installed. The fan and ducts for the battery room service are lead covered.

Aside from the space in the auxiliary bay already mentioned, ventilation is arranged through natural air flow. The main turbine room is ventilated by louvres placed in the turbine house roof and air is supplied through swinging sash in the main windows.

Switch and Control House

The switch and control house forms a separate problem. This building houses the high voltage electrical switch gear and contains the main control room. None of this equipment must be endangered by having piping in its proximity, or the possibility of steam and water leaks. In aisles or other spaces not containing high voltage equipment, direct radiation is installed and ventilation supplied by swinging sash in the windows. The high voltage equipment is located on three floors and arranged in longitudinal aisles. These floors must be kept isolated from each other. Certain portions of this equipment generate heat which must be removed in accordance with maximum allowable temperatures. The entire building must be maintained at a temperature suitable for reasonable working conditions, and also to prevent any possibility of moisture being condensed on the electrical structures and equipment. The operating room must have a comfortable temperature at all times.

In general this building is filled with a mass of electrical equipment, busses and cable, the arrangement and location of which control the general space requirements. The heating and ventilating system has to be subordinate to these but by attacking the problem at an early period in the plant design and on a broad comprehensive basis, it is believed that a system has been installed which accomplishes the purpose and yet is very simple.

Switch Bay

The steam for heating is drawn from the central source in the power station. Supply and return lines run underground and are placed in insulated tile conduit with suitable drains, anchors, expansion joints, and manholes.

The switch bay containing the phase rooms and mechanism floor is heated and ventilated by a system of vertical supply and exhaust ducts. These carry air which performs both functions; that is, heating in winter and "flushing out" or cooling in summer. There is a supply fan and vento heater at the base of the supply system and an exhaust fan at the top of the exhaust system. Each floor has its own vertical supply and exhaust ducts with branches run to one end of the phase aisles. The supply ducts admit air to one end of these aisles and the exhaust ducts remove it at the other end. The aisles themselves are utilized to pass the air from the vertical supply system to the corresponding exhaust system. Ducts in the aisles themselves would have been objectionable due to proximity to electrical equipment and would also have been difficult if not impossible to install.

The complexity in the requirements of heat loss and heat generated has been handled in a very simple manner by utilizing the "flushing out" principle. In this, all compartments, some of which generate heat and some requiring heat, are brought to the same general condition by flowing through them, air of a moderate temperature; that is approximately 75 deg. in winter, or the outdoor temperature in summer.

For possible extreme heat conditions an exhaust fan is installed on the roof which can be used to increase the amount of heat and air removal and also to hasten the removal of smoke in event of a fire or short circuit. This fan is located in a penthouse on the roof with its suction connected to the main ventilating shaft, and its discharge to the atmosphere. It is arranged so that when the fan is started a damper in the gravity ventilating shaft is shut automatically, and in doing so the air is bypassed through the fan to the atmosphere instead of going directly outdoors as in the case of natural ventilation. For emergency service, especially the removal of smoke, the fan is started and the damper closed from push button stations on each floor. These push buttons are interlocked so that the equipment can be stopped only from the station where it was started.

No dampers except the automatic one at the exhaust fan are manipulated at any time. They are set for proper distribution and then locked in position. For electrical operating reasons the doors to the different electrical compartments are normally closed and locked. The ventilating system, therefore, remains in balance and at only one place requires operating attention; that is, the supply fan and heater.

Conclusion

In general the aim has been to secure a system that is simple, and that requires the minimum of operating attention. Fans and pumps have been dispensed with wherever considered possible and gravity used to a considerable extent. The design was worked out in conjunction with the power problems and not as an after-thought. The design of the building and arrangement of equipment was utilized to solve many of the heating and ventilating problems by eliminating them.

Treating Basement Walls to Prevent Seepage

REPAIRS TO leaky basements depend upon local conditions which make each case a problem in itself and suggestions, therefore, on this subject are difficult to make. A few typical examples, however, may serve to illustrate the general principles to be followed with modifications according to the requirements of the case as leakage in the basement may come from any one or more of a number of sources.

Repairing Walls from Outside

It is best to make repairs to a wall on the outside, that is, on the face opposed to the incoming water. Under such conditions a trench wide enough to work in is dug to the bottom of the foundation and the wall surface thoroughly cleaned by brushing and washing to remove all dirt and loose material. If the construction is stone, brick or other masonry, mortar joints should be raked out to a depth of ½ in. If there are cracks in the wall through which seepage has appeared, these should be cut back to form a V-shaped groove and filled with a 1:1½ cement-sand mortar mixed to the consistency of moist earth. This should be well rammed into the crack with a calking tool or ball peen hammer.

Grout of portland cement and water mixed to a consistency of thick cream should then be applied to the surface and immediately followed with a coat of 1:2 cement-sand mortar ⅜ in. thick. The grout should be mixed only in small quantities that can be used within 30 min. after mixing and plastering must follow before the grout has commenced to harden. The first coat should be well worked with a wooden float and when hardened sufficiently so that it may be roughened without injury to the surface, it should be scratched with a saw-tooth paddle or piece of metal lath so as to provide a good key for the final coat of mortar which is also ⅜ in. thick. The mortar should be mixed with just enough water to make a stiff plaster.

If it is possible to secure drainage to some suitable outlet, a line of drain tile should be laid in the bottom of the trench and backfilling made as described in a preceding article which appeared in the November 15, 1924, issue of Power Plant Engineering. Should an examination of the basement in the beginning show that seepage occurs through a crack where the wall joins the floor, the crack should be cut out to a depth of 1½ to 2 in., forming a narrow groove and the space filled with hot tar or a mixture of tar and sand. If there is seepage through cracks in the floor, or through porous spots due to improper mixing or placing of the concrete, however, a new floor should be laid over the old one with a tarred joint at the walls. In severe cases it may be necessary to place over the old floor surface a layer of burlap or felt mopped with hot tar or pitch before laying the new floor. The slabs should ordinarily have an area not greater than 100 sq. ft. and it is best to lay alternate slabs first, giving the edges of the hardened slabs a thick coat of hot tar before concrete for the intervening slabs in placed so that the joint is made more watertight.

Repairing Walls from Inside

If it is not possible to get at the outside of the old wall, then the plaster coat must be applied on the inside following the same methods of cleaning and roughening of surface and applying the plaster. If it is impossible to carry out this work during dry weather, seepage through cracks has sometimes been relieved by inserting pipes to serve as weep holes in the wall which are plugged after the rest of the work has been completed. The plastering on the inside surfaces must be given a chance to harden properly before subjecting it to the seepage of water, otherwise the seepage would be likely to interfere seriously with the bond on the old wall surface.

Where pressure of ground water during wet weather has cracked the floor, causing the basement to be flooded periodically, the floor surface must be covered with two or three layers of burlap mopped with hot tar or pitch, and this waterproofing membrane should extend a distance of 1 ft. or so up the inside of the basement wall. The new floor constructed on this foundation should have a thickness depending upon the amount of upward water pressure which must be overcome. The plastering on the wall should be carried down over the membrane near the floor.

Disposing of Surface Water

Relocation of down spouts or construction of gutters to take the runoff from the eaves will also assist in carrying the surface water away from the basement wall and if the ground outside of the basement slopes toward the wall, the soil around the basement should be banked up higher.

NEVER USE kerosene or coal oil in an air cylinder to clean it out: This is a very dangerous practice and should be absolutely prohibited.

Careful Operation of Reboiling System Gives Good Ice

By W. H. Howze

IN THE ice plant using the reboiling system, I believe that the improper use of oil is the cause of more trouble than the rest of the separating system. My experience has been that many operators not only use too much oil but also do not pay much attention to the separating qualities of the oil when it is purchased. Few plants are equipped to test oil and, when the salesman speaks of viscosity or flashing tests, he is talking "Greek" to the operator.

To test oil for separating qualities quickly and easily, fill a bottle with distilled water, as hot as you can handle it, pour in about a tablespoon full of the cylinder oil to be tested and shake it well. If the water clears up at once the oil is safe for your use; but if it is slow about coming to the top and leaves the water with fine particles of the oil mixed with it, or a milky color, let it alone—you will have trouble with your system as long as the oil lasts. While the oil may be of good quality for other purposes it is not satisfactory for your use.

Some operators recommend passing the steam from the engine through a vacuum trap filter, but by passing the exhaust through a closed water heater, with a baffle plate steam trap near the condenser, the same results will be produced. Also the equipment will not cost as much and there is no pump or trap to operate.

After the steam passes the heater and trap, it goes into the condensers, which should be erected high enough for the water to gravitate through the rest of the system. The tower is generally 15 ft. high or more. The reboiler tank or tanks can be erected on the same floor with the condenser, just enough lower for the water to gravitate from the condenser to the reboiling tank. No pump is needed or used in this system.

Some engineers want from one to five tanks for the water to pass through; this is not necessary, as one tank, deep enough to hold three or more ice cans of water, will usually be enough, depending on the size of the plant. This tank should have a baffle plate running the length of the tank, dividing it in two, except about 6 in. at one end. The water from the condensers enters on one side of the baffle at the bottom, passes around the baffle and is taken out at the bottom of the tank, opposite the intake from the condensers. Near the top of the tank, over the discharge from the reboiler, is the overflow, which should be connected to some waste water line or sewer. The oil and scum rise to the surface and are skimmed off as the tank overflows, which should be between the filling of each ice can in small plants, or between the filling of several in large plants. There will have to be more water flowing into the reboiler than is used for making ice, in order to take care of this overflowing that does the skimming. Most plants, however, have a surplus of condensate.

In reboiling the water from the condenser in the reboiler, twice as many coils should be put in the bottom of the reboiler as there are for live steam. These coils can be made at the plant. They should be connected to the exhaust of the steam pumps, which is generally sufficient; if it is not, tap the main exhaust line for the remainder and let the exhaust from these coils go to the air.

Next the water flows by gravity from the reboiler to the cooling coils, which can be single or double pipe, depending on space and upon the individual ideas of the erector. Here the water is cooled, care being taken to watch the flow of it. With the double-pipe cooler, let the cooling water and the water from the reboiler flow in opposite directions. With the single pipe cooler, let the water from the reboiler enter at the bottom and discharge from the top of the coils. It is a good idea at this connection to have a place to admit live steam through a ½ or ¾-in. pipe, to overcome the air-locking of pipes.

Still flowing by gravity, the water goes now to the filters, which are generally of the charcoal type. Each filter must be connected so that the water can be bypassed in case of trouble in the filter. Water must enter the top of the filter and pass out at the bottom, because, if the filter discharges from the top, any sediment or oil will be carried to the storage tank. The highest point of the filter must have an air vent to release the air from the line in case of air lock, which should not happen except on starting up the plant, or through the carelessness of some employe.

From the filter the water passes to the storage tank, its flow regulated by a float valve. It is a good idea to have a gate valve in the line near the float, to use in case of emergency or repairs to the float valve. The float valve must be enough lower than the reboiler to let the water flow through it—two feet at least—more will be better. The position of the cooling coils and the filter does not make any difference. The intake of the water and the discharge is what you have to watch. The water in the storage tank is cooled by a coil connected in series with the coils of the ice tank and the ice machine. In this way, the refrigerating effect of the plant is utilized most effectively, whereas with direct expansion in the storage tank, the ice tank is robbed and more is lost than gained. The can filler line is now connected about 10 in. from the bottom of the tank so as not to get the sediment.

Notes on Piping

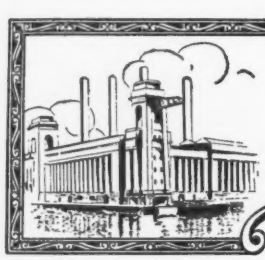
Lap weld pipe, commonly known and designated as O. D. pipe and measured on the outside, can be obtained in diameters from 14 in. to 30 in. and thicknesses from ¼ in. to 1⅛ in. The lighter pipe is used for low pressure work, steam, water and vacuum lines; the heavier for high pressure work.

Hammer Weld pipe can be obtained in sizes 14 in. up to 120 in., and in thicknesses from ¼ in. to 2 in. It is adapted for use in low pressure steam mains, large size gas mains, vacuum lines, circulating water lines and hydro-electric developments.

Pipe is pickled to remove all scale, painted and then treated for whatever purpose it is to be used. If for circulating water or other lines buried in the ground, it is covered with heavy asphaltum paint.

Hammer welded pipe costs less per foot erected or laid in the ground than cast iron or bell and spigot pipe. The cost of supporting this pipe is much less on account of the great reduction in weight. The steel from which this pipe is manufactured is special low carbon open hearth steel plate, which is more resistant to corrosion than ordinary commercial steel plate. This pipe can be furnished without additional cost, having a copper content as high as 0.09 which adds materially to its resistance to corrosion.

Cast iron pipe manufactured in a wide range of sizes, having either flanged or bell and spigot ends, has high corrosion resisting qualities and is more durable than wood-stave pipe.



LETTERS DIRECT FROM THE PLANT

Overhauling a Small Ice Plant

SOME TIME ago, when I took charge of our small hotel plant, my first job was to overhaul and start the ice machine. The gages were right, but the low pressure side indicated no pressure and the high side had a pressure of about 12 lb. as the machine stood shut down on a hot day, so the ammonia the system held would do more heating than cooling when things were working. The double-pipe condenser tubes were tight; but when I poured a solution of lye through them, the lye came out like thin mud.

We first pumped a high vacuum on the low side; this vacuum held for several hours, so everything looked good enough to me. With the vacuum on the low pressure side, the condenser pressure was only 20 lb. with no water running on it. I blew air out of the condenser, right into the engine room, and the pressure dropped to 10 lb. before the ammonia became bothersome; 200 lb. of ammonia was then pulled into the system and it was all right.

Besides the refrigerator boxes, we have a 25-can ice tank out of which 8 cans are taken every day. Raw water was used in the cans, without agitation, so the ice was white. Since it was considered too much of an expense to buy an air-blower, I found an old electric vacuum sweeping machine of the size that can be carried around, overhauled it and put it in running order, cemented a ¾-in. nipple in the discharge opening and had a blower.

Rubber hose carries the air from this blower to a header lying across a row of five can-covers; the header is made up of ½-in. nipples and ½ by ⅛-in. tees. Here ⅛-in. drop-pipes are connected by means of rubber tubing to short ⅛-in. nipples screwed into the tees; the drop pipes extend down in the water in the cans. Holes are bored in the tank-covers, so that the header with its pipes can be lifted out when the ice closes up. If the pipes should freeze in, the header can be removed by pulling the rubber tubings off. Caps with $\frac{1}{16}$-in. holes drilled in them are screwed on the end of the drop-pipes, so they will all get the same amount of air. This apparatus makes clear ice.

Brooklyn, N. Y. E. MATZAN.

Recovering Broken Plunger of Deep Well Pump

AT ONE plant where I operated a deep well pump, the ball guard broke on top of the plunger of the pump, giving us an interesting problem in getting the ball and plunger out. The top portion of the guard came up with the sucker rod and left the plunger and ball resting on the suction valve.

To get the ball out, we first procured a piece of 3 by 3-in. fir about 24 in. long, and bored a hole down one end, $\frac{1}{16}$ in. smaller in diameter than the ball and in depth twice the diameter of the ball. The other end was drilled about 6 in. deep for ½-in. pipe to screw in. Saw-cuts were then run down the corners at the end where the large hole was, as shown in Fig. 1, to allow the block to spread over the ball without splitting. The block was then screwed onto a length of ½-in. pipe and lowered down the casing, pipe being added until the block reached the ball. Then the end of the pipe was hammered down so that the block went over

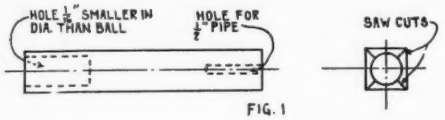


FIG. 1

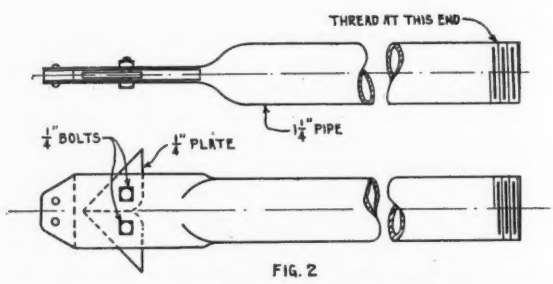


FIG. 2

FIG. 1. SHOWS BLOCK FOR CATCHING BALL
FIG. 2. HARPOON FOR REMOVING PLUNGER

the ball and held it so that it could be drawn clear of the well.

To get the plunger out, we made a harpoon out of 1¼-in. pipe and ¼-in. iron plate as shown in Fig. 2. A 1¼ by ½-in. reducing coupling was screwed on the threaded end of the harpoon so that it could be lowered on the ½-in. pipe. The barbs were pivoted on ¼-in. bolts and were free enough to fall by their own weight, so that when they were through the hole in the plunger they assumed a horizontal position, the short sides touching their full length and the horizontal sides catching both sides of the plunger below the valve seat.

With a pair of light blocks it was an easy matter to get the plunger out of the cylinder, when two men pulled it up to the surface without much trouble.

Tranquille, B. C. J. P. BOLTON.

Reinforced Concrete Designed From Tables

REFERRING to Mr. Nutter's remarks in the Feb. 1 issue on the use of reinforced concrete for foundations in power plant work, there are excellent tables in the section of Marks' Handbook on building construction for the proportioning of both floor slabs and beams; from these tables a suitable design can be selected without recourse to much mathematics. The best feature of a table such as this is that it gives the economical proportion of steel to concrete

and the proper breadth and depth for various loadings, not always easily found by one not working constantly with such things. For running machinery, it would be advisable to choose beams and columns for considerably more than the weight of the apparatus to allow for extra stresses due to shocks and vibration.

Perhaps one reason the average engineer has been shy of such construction is that it requires more care in proportioning and mixing the concrete and in locating the reinforcing than can usually be obtained from the usual run of labor obtainable for small jobs, or even beyond what he feels himself capable or experienced enough to supervise properly.

We have used considerable reinforced concrete, not so much for machinery foundations, for these have not been required, as for retaining walls and floors. None of these has failed, as they were proportioned according to rule with the usual factor of safety. We have found it difficult to get proper mixing of the standard proportions, such as 1:2:5, when mixed by hand, and have usually had to make our concrete a little richer under such circumstances. Therefore, when a job runs into 25 cu. yd. of concrete or more, it is cheaper to hire a mixer or even to give the job to a contractor, as he can make quite a saving both on labor and cement.

New Haven, Conn. H. D. FISHER.

Proper Care of Gage Glasses Prevents Trouble

MUCH HAS been written about the use and abuse of gage glasses, but one rule that is more important than any other is to allow absolutely nothing to touch the internal surface of the glasses while they are in storage. They should not be hung up with a cord passing through them because a bit of grit may be embedded in the string and scratch the glass. To store glasses in bulk, the safest way is to roll each glass carefully in a sheet of newspaper and pack the glasses in a box.

Never pull or push a swab of cotton or cloth through a dirty glass unless you have failed to clean it with a solution of soda, acid, or by some other safe method. A dirty glass usually has a lot of grit on its inner surface. When the swab starts on its journey through the glass, it may pick up some of this grit and make a fine scratch upon the inner surface from one end to the other. This scratch may be invisible to the eye but may cause the glass to break after it has been exposed to wide temperature variations.

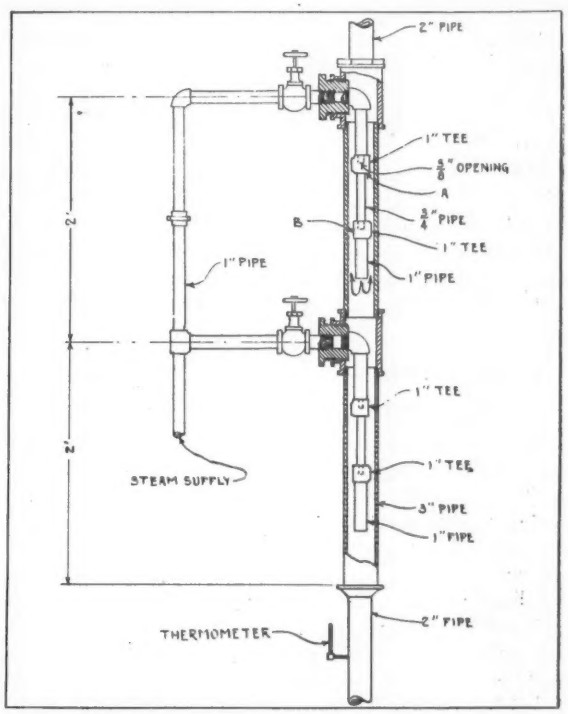
Do not be in too great a hurry to blame the manufacturers. The chances are good that either yourself or one of your helpers is to blame for a broken glass.

Toronto, Ont. JAMES E. NOBLE.

Emergency Water Heater Uses Steam Jets

AS THE factory uses a lot of hot water and at times the temperature of this water gets a little low, I made an emergency heater as shown and put it in the supply pipe between the tank and the factory. The supply piping being 2-in. brass pipe, I used 3-in. brass pipe for my heater. I put in two steam jets to be sure I had heat enough, but one answered the purpose.

The 1-in. brass pipe in tee A is reduced to ⅜ in. The outlet in tee A is ¾ in.; that is reduced to ½-in. in tee B. The openings in tees A and B are on opposite sides. The 1-in. tail pipe in tee B is for circulation; as the velocity through the 1-in. pipe is greater than that of the water being used, the circulation would be back around the 1-in. pipe to the openings in the tees A and B. The high velocity caused by these jets stops the vibrating of the pipe and eliminates the cracking sound you get by putting steam



EMERGENCY HEATER, SHOWING STEAM JETS AND PARTS MADE FROM STANDARD FITTINGS

direct into the water with the amount of water ordinarily used. Using this heater, I ran the temperature from 140 deg. up to 200 deg. with one jet.

Brookline, Mass. R. B. ROWE.

Force-Feed Lubricator Has Advantages Over Hydrostatic Type

AMONG THE many interesting things in the Jan. 15 issue, I was particularly attracted by the comments of James E. Noble and W. H. Wakeman on lubrication. I agree with what Mr. Noble has said about the virtues of the hydrostatic lubricator, but there are some other points that may be considered as disadvantages. These disadvantages are:

1. Possible changes in surrounding temperature, which influence the rate of feed of the oil.
2. The range of rates of feed is within comparatively narrow limits.
3. The rate of feed is not absolutely constant over long periods of time.

These disadvantages mean that considerable attention must be given to the lubricator during operation in order to maintain uniformity of feed. Where there are only one or two lubricators to be taken care of and the attendant is not crowded with other duties, the disadvantages just referred to are not serious. But in plants where there is a

large number of engines, pumps and other machines requiring internal lubrication, then the hydrostatic type of lubricator is not as efficient as the mechanical force-feed lubricator.

This type of lubricator feeds the desired quantity of oil that it is adjusted to deliver, in spite of any temperature change that may occur. Also, it continuously and constantly feeds the quantity of oil for which it has been adjusted, as long as any oil remains in the receptacle, the adjustment once having been made. After the force-feed lubricator has been filled with oil, the feed will be as regular as the speed of the engine itself and it will not require any attention until the regular time for refilling. In these days of economy and efficiency, a regular, controlled feed of cylinder oil at all times is of the greatest importance in many plants. In such cases, the mechanical force-feed type of lubricator is undoubtedly preferable to any other type. Still there is a large field of usefulness for the hydrostatic lubricator as well, and it will always have its advocates.

Brooklyn, N. Y. CHAS. J. MASON.

Pipe Vibration Caused Noise and Necessitates Furnace Repair

SEVERAL years ago, the writer had charge of the erection and operation of an industrial power plant consisting of horizontal tubular boilers and a simple non-condensing Corliss engine. In starting up, everything went well except that there was excessive vibration of the steam pipe, which communicated itself to the boilers. This pipe extended from the 14-in. header at an angle of 45 deg., coming down to the engine with a quarter bend. We made every effort to anchor the pipe, but without success. In a couple of years, the vibration had been so detrimental to the brickwork that the furnaces were ready to fall down and had to be rebuilt.

While doing this, we installed a steam receiver near the engine; this received had a volume 2½ times that of the cylinder. The quarter bend was taken from the throttle and used to connect the straight run of pipe to the inlet nozzle on the receiver. An 8-in. U-bend connected the receiver to the throttle. This construction stopped the vibration but now the U-bend, under the action of the steam, showed a tendency to draw its feet together and then to stretch them out like a caterpillar negotiating its way along a twig. This was overcome by making a strut of 2-in. pipe and securing it across the legs of the U, just above the flanges. This strut was not rigid enough to prevent expansion and contraction, but it damped the vibration. It has always been our belief that this pipe, considering its short length, would not have vibrated if elbows had been used instead of bends. A 24 by 42-in. Corliss engine at 100 r.p.m. certainly gives the steam a kick and possibly a more rigid system of piping might have given less trouble.

One of the interesting problems connected with rebuilding the furnaces was to support the two 50-in. guyed stacks in place while the brickwork was removed and rebuilt. First we made clamp bands of 1 by 4-in. machinery steel bar, leaving the ends of the clamps projecting about 10 in. Then 8-in. timbers were placed on the I beams supporting the boilers (these beams were supported by cast columns), posts were placed under the other ends of the timbers, and the clamps were fastened to the stacks, allowing the projecting ends of the clamps to rest on the timbers and take the weight of the stacks. After the timbers were thoroughly braced, the project went through without a hitch.

When rebuilding these furnaces, we had heavy channels of cast iron made and held against the backwalls of the furnaces by long rods laid in the side walls. These channels help materially in supporting the backwalls in place.

It might be supposed that the header and piping were too small and that this caused the vibration referred to, but I hardly think so. The header was 14 in. in diameter, the pipe to the 600-hp. engine 8 in. and the risers from the 200-hp. boilers, 6 in. In our efforts to find the cause of the trouble, we attached the steam engine indicator to various parts of the boiler piping and the variation in pressure was so slight as to be imperceptible on the card.

Anderson, Ind. J. O. BENEFIEL.

How Is an Engineer's Success Measured?

IT IS STILL a common occurrence to hear a certain type of power plant engineer draw comparisons between stationary engineers and other workers, such as stone masons or electricians, usually with the financial and other advantages listed in favor of the latter. I am getting along in years and about 35 of them have been passed in power plants, many times as chief. So far as money is concerned, I still have lots of room to enlarge my roll of bills before it gets too large for my pocket. My bank balance has never gone over four figures. Is this the fault, then, of the engineering business or of the man? I say it is the fault of the man.

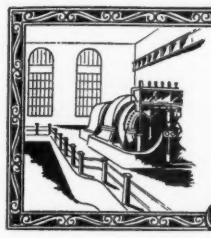
I have always been just an ordinary fellow with average ability, but with a desire to do my best for my employer in exchange for the necessary cash to pay my monthly expenses. I have studied engineering text books and journals for many years, but I have sadly neglected most other lines of study. I believe that a study of the subject would show that most of the failures are in my class, when success is measured in money.

I believe no business requires as much study along different lines to insure financial success as engineering. Nevertheless, some men cannot recognize success unless money is the reward. Although I have no great amount of money, after a life of service as an engineer, I have never felt the need of a meal or a dollar. I owe no man a cent and I have a fine lot of grown-up children and a finer wife.

For some years before I retired from the engine room as a worker, I paid the Government 5 per cent of my wages for promising me a life annuity after I reached the age of 55. I now receive a check from the Government every month and shall continue to receive these checks as long as I live. I still visit power plants and often one of the younger generation of engineers is glad to have permission to call on the old man and ask his advice in reference to some problem in connection with modern equipment. Often I can give the information required. I have a fine radio set and can sit at ease and enjoy concerts and lectures, from all over the country. I do not need to work unless I get tired of idleness.

Has engineering given me success? I feel that it has. Any ordinary fellow who will not be satisfied with returns for his labor, such as described in the foregoing, had better get into the bootlegging or undertaking business.

Toronto, Canada. JAMES ABERDEEN.



QUESTIONS AND ANSWERS

Why Riding-Cutoff Engine Pounds

FROM THE cards submitted from a pounding engine by E. H. W. in the Feb. 1 issue, it appears from diagram A that the engine is very large for the load when 130 lb. steam pressure is carried, especially when run condensing.

Cutoff at G is hardly noticeable and at G′ admission and cutoff occur so close together that there is just sufficient steam pressure to raise the indicator to full boiler pressure before the cutoff valve closes. It also appears that the valves leak somewhat, as shown by the hump K in the expansion line of the head-end card, though this may be caused in part by the reaching of the governor to hold down the speed and equalize the load between each end of the cylinder. The expansion line in the crank-end card drops quickly to the point K′, showing that this valve does not leak much while the piston is traveling that portion of the stroke; however, as it holds up quite high for the remainder of the expansion line, to the point of crossing the atmospheric line, the indication is that the cylinder is getting steam after the valve is supposed to be closed, or after cutoff has taken place. This, of course, would give the high terminal pressure at the points of the two cards T-T′.

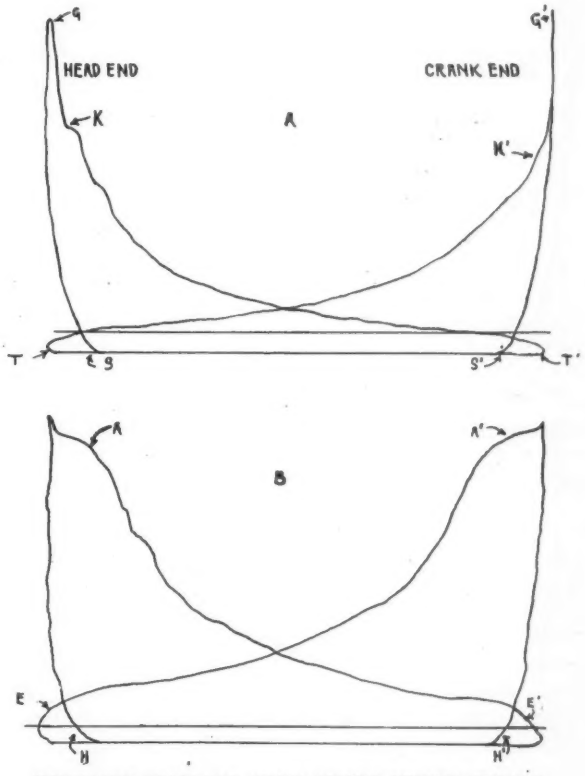
If steam did not enter the cylinder after cutoff took place, the expansion line would be drawn down into a negative loop at the points T-T′ on account of such a short cutoff; that is, there would be a vacuum created in the cylinder before the exhaust port opened, then this vacuum would equalize with that in the exhaust pipe. This high terminal pressure at T-T′ also indicates that the exhaust port opens a little late, which, with the average riding cutoff engine having the main valve operated by a fixed eccentric, would cause late closing of the valve for compression which is shown to be very slight at S-S′ in the A diagram and at H-H′ in the B diagram.

If the valve opens late, it will also close late and there is insufficient compression to check the energy stored in the piston, piston rod, crosshead and connecting rod to bring them to a quiet stop at each end of the stroke. Hence there is a pound but the greater part of this pound should appear in the crank and crosshead brasses although it may sound in the cylinder. If the piston became loose on the rod in the cylinder, which sometimes happens if the nut loosens or when the rod becomes stretched from the engine getting water into the cylinder, there would be a pound in the cylinder.

This can be found by removing the cylinder head and trying the nut with a wrench, or trying the key, if keyed on, with a hammer. If it is a built-up piston, examine it thoroughly, even though the cylinder has just been rebored. Adjusting bolts and follower bolts have often come loose and wrecked an engine.

Compression must be more for an engine running condensing than for one running against back pressure, or exhausting to atmosphere. The main valve must be set to close earlier, which would give earlier release, less terminal pressure and more compression; the compression being greater, the pound in the pins and crosshead should cease if they are keyed up properly.

At the beginning of the stroke, the high boiler pressure gives the piston such a sudden slam in such a short portion



INDICATOR DIAGRAMS FROM RIDING-CUTOFF ENGINE SHOWING POINTS REFERRED TO

of the stroke that it is unstable in speed and causes the governor to reach constantly to maintain equilibrium; therefore, the weights may strike the stop pins at times, causing more pound.

Changing the setting of the main valve to get more compression would throw the "rider" or cutoff valve out of place, and this valve also would require resetting. It is safe to set the engine at about 20 per cent cutoff. Furthermore, since the pound is much less with 110 lb. boiler pressure, the engine will run more smoothly and economically if the boiler pressure is reduced until the engine cuts off at 25 to 30 per cent of the stroke. Then, too, it might be better to run non-condensing on the average load. The type of valves and governor used have much to do with the accuracy and ease of maknig these changes.

Cambridge, Mass. R. A. CULTRA.

Calculating Transformer Sizes and Short Transmission Lines

TRANSFORMER circuits are to be installed, as shown in the enclosed sketch, to supply the loads indicated at B_2 and C_2. Power is supplied to transformers at A from 480-v., 3-phase generators, at 0.8 power factor, transmission line ABC being outdoors.

1. Is the transformer bank at A the correct size? How is it figured?

2. How is the size of wire between AB and BC figured?

3. What size switches and circuit-breakers are needed at the points shown?

4. Please explain how the current and rating of the transformers are calculated. E. M. D.

ANSWERS

Apparently the transformers at A have not been figured for the actual load at that point. The method of finding

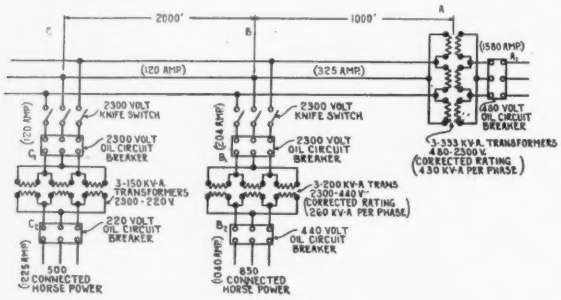


DIAGRAM OF PROPOSED TRANSFORMER CONNECTIONS. DATA IN PARENTHESES WERE CALCULATED FROM THE FIGURES GIVEN

this load is as follows. The load at B_2, as given in your sketch, is 850 hp. Using the formula $P = \sqrt{3} \times E \times I \times$ p.f., (in which P is the power in watts, E the voltage, I the current in one conductor of the 3-wire system, p.f. the power factor and $\sqrt{3} = 1.73$) we find that $I = (850 \times 746) \div (1.73 \times 440 \times 0.8)$, from which I, the current at B_2, equals 1040 amp. This is the current per phase, or the current to be carried by each wire of the three-wire system. Since the total power on one side of the transformer is practically the same as it is on the other, making a small allowance for transformer losses, the current will be much less with the higher voltage at B_1 to get the same amount of power. I at $B_1 = (440 \times 1040) \div (2300 \times 0.98) = 204$ amp. per phase. (0.98 is assumed to be the efficiency of the transformer.)

By using the same formula, the current at C_2 is found to be $(500 \times 746) \div (1.73 \times 220 \times 0.8) = 1225$ amp. per phase. The current at $C_1 = (220 \times 1225) \div (2300 \times 0.98) = 119.8$ amp. or approximately 120 amp. The total load then is approximately 324 amp. at 2300 v. Then, since the current in the transformer coils is $I \div \sqrt{3}$ for delta-delta connections, as will be explained hereafter, the rating per phase is $2300 \times (324 \div 1.73) = 430{,}000$ v.-amp. $=$ 430 kv-a.

It seems, therefore, that the transformers at A, rated at 333 kv-a., have not been figured correctly.

Note also that the currents calculated above are the currents, actually flowing in the circuits, that the system must carry. The current that flows without doing work is included in this amount, since it has been taken care of by the power factor in the above formula.

2. In order to find the size of wire necessary in circuits AB and BC, it will be necessary to find or assume the voltage drop in these circuits. If we assume that 23 kv-a. is allowed for power losses, the loss will be approximately 5 per cent, which is a reasonable figure for circuits of such length. Then, if the power loss per phase is 23,000 volt-amperes with 325 amp. flowing, the voltage drop is 72 volts. If the total load were carried from A to C, we could use this as the allowable voltage drop, but since the line from A to B will carry 325 amp., the full load, and the line from B to C will carry only 120 amp., we may assume that the voltage drop from A to B will be 24 v.; the drop from B to C will probably be more than the remainder. We believe that if the drop from B to C is assumed to be 55 v., it will be satisfactory. By allowing such a voltage drop, we avoid the use of too much copper in the transmission line. By using Kelvin's law we could make a more accurate and theoretical determination of the most economical size of conductor to use, but for such a short line, the method used here is sufficiently accurate for practical purposes. To find the size of wire necessary, the following formula may be used:

$$A = (10.8 \times I \times D \times \sqrt{3}) \div E$$

In this formula A equals the size of the wire in circular mils, I equals the current in one conductor, D equals the length of the circuit in ft. and E equals the allowable voltage drop. Then, for section AB of the line $A = (10.8 \times 325 \times 1000 \times \sqrt{3}) \div 24$, which equals 250,000 circular mils area.

In the same way, the area of the wire from B to C equals $(10.8 \times 120 \times 2000 \times \sqrt{3}) \div 55$, which equals 81,500 c.m. Number 1 B. & S. wire has an area of 83,690 c.m., so that it could be used here. Since these transmission lines are all outside, bare wire could be used.

3. Since you know the current flowing at various points in the cricuit, it will be easy to tell what size switches should be used. You may wish to allow a certain amount of overload capacity in these switches, which will, of course, be determined by the conditions under which your motors are running and by the load on the circuit breakers.

In regard to the size of these circuit breakers, the only thing we can say is that different manufacturers have different methods of rating them. In general, the manufacturer makes an allowance for overload capacity, which is, to a large extent, determined by the overload capacity of the motors and the short-circuit conditions in the circuit. Since we have given the amount of current flowing at the various points in your circuit where oil circuit breakers are to be placed, you can probably tell what this allowance for overload should be better than we can.

In regard to the size of the circuit breaker at A_1 on the generator side of transformer A, the current at $A_1 = (2300 \times 324) \div (480 \times 0.98)$, which equals 1580 amp. The breaker must carry this current, together with such overload current as may be allowed.

4. It is not easy in a letter to answer your questions in regard to transformer connections, inasmuch as the subject itself is a big one and the calculations are, in some cases, unusually complicated. The connections in your transformers, as shown by the sketch, are delta-delta. With such connections, or with the closed delta connections, the current in the transformer windings themselves equals

I ÷ √3, where I is the line current and the capacity of a group of such transformers is √3 E I kv-a.

With open delta connections, assuming that each transformer will have a capacity of 1.5 E I, it must be capable of carrying 1.73 E I kv-a. Therefore, the single-phase rating of the transformer must be 1.73 ÷ 1.5 = 1.155 or 15.5 per cent greater than one-half the group rating.

Ratings of the transformers at C, with delta-delta connections, can be figured by multiplying the voltage, which at this point would probably be 2230, by (120 ÷ 1.73), which equals 155 kv-a. As a check on this, 500 hp. at 0.8 p.f. equals 460 kv-a., or 152 kv-a. per phase. Using the same method, the transformers at B figure out to be 260 kv-a. per phase instead of 200 kv-a., as noted on your sketch. It is possible that if they were figured to be 200 kv-a. a different basis of rating was used, or that an error was made in writing the size on the sketch.

Sooty Tubes May Cause Low Boiler Capacity

J. H. STATES in the Nov. 1 issue that one of his boilers would not deliver over 50 hp. since installation and at the finish of a 10-hr. run, it takes 2 or 3 days for the brick work to cool, bearable to the hand.

Testing with the draft gage, no doubt will lead to a discovery of the trouble. But since J. H. says the boiler burns 3 T. of coal in 10 hr. and that he cleans his tubes only twice a week, it seems to me that the following will be of some help.

My method of blowing tubes, which has proved successful, is as follows: If care is taken, when blowing tubes in an H. R. T. boiler, to leave the soot blower at each tube long enough, a muffled sound will be heard at first, gradually merging into a more hollow sound which indicates the tube to be cleaned of soot. If, on the other hand, the tube is not given steam from the blower long enough, the soot simply piles at the rear ends of tubes.

Now, to illustrate: I have fired this amount of coal (3 T.) in one of my boiler furnaces in 12 hr. (blowing the tubes before starting and just before finishing the run). At the end of the 12 hr., I would find soot well covering the tube sheet and plenty of it lying in the bottom of tubes, enough to warrant blowing.

In plants running on three 8-hr. shifts, it is one of the rules of routine that each man blow his tubes, either beginning or finishing his watch. Twice a week is not sufficient when 3 T. of coal are burned in 10 hr.

In my own case, I always notice a quicker "pick-up" of the boiler immediately following the blowing of tubes. My draft gage will show a difference and I can close my hand dampers another notch or two. I am referring, of course, to operation with a fairly steady load.

Worcester, Mass. LEROY BLAKE.

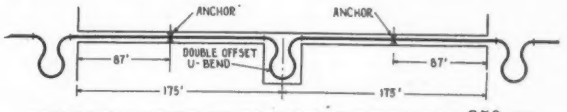
Underground Pipe Expansion Taken by Bends

IN YOUR reply to A. G. S. in the Feb. 1 issue, regarding expansion in a 350 ft. run underground of 5 in. pipe, for steam at 225 lb. with 100 deg. superheat, the difficulty of draining the expansion bends is mentioned. In underground work, the bends are usually laid horizontally in pits and have the same grade as the rest of the pipe, draining themselves without any difficulty whatever.

In a case of this sort, I recommend laying out the line approximately as shown in the sketch, placing a pit for the central expansion bend somewhere near the middle of the run and anchoring the pipe in the duct about halfway between this and the ends. The double U bend mentioned, of 60 in. radius with a capacity of 8¼ in. expansion, would be suitable for this middle bend or, if the pipe were purposely cut about 3 in. short between the anchors and the bend pulled open cold by using long bolts in the flanges when making up, a smaller bend of 42 in. radius would be suitable.

It is desirable to anchor pipes of this nature so as to bring the expansion where it is expected, otherwise, owing to friction of supports or accidental blocking of the pipe, most of it might be concentrated at one bend and might overstress, the other bends doing nothing. This procedure also obviates the necessity of providing for excessive motion at any of the supports.

At such high temperatures and pressures as this, I would much prefer bends to slip joints, owing to the difficulty of properly lubricating and maintaining the packing of



PROPOSED LAYOUT OF EXPANSION BENDS FOR 350 FT. UNDERGROUND HIGH PRESSURE PIPE LINE

the latter at such high temperatures. More attention and frequent inspection might be required and, while I have no definite figures, I feel that the four joints would cost more than the three bends for this size of pipe. No more manholes would be required for the slip joints, because, with the anchors arranged as shown in the sketch, two slip joints could be located in the central manhole, the short connecting piece in this case also being anchored. On the score of safety the bend is somewhat to be preferred, for, if a slip joint sticks the pipe must buckle somewhere, whereas with a bend its resistance to expansion is small and definitely known. It might be possible to avoid the use of special bends at the ends by approaching and leaving from the sides of the underground section. Where buildings must be avoided with slight zigzags, such a layout is often used to avoid installing regular expansion joints.

Under any conditions, the line should be pitched to drain with the flow of the steam, even if it is necessary to install a drip leg and riser at intervals to keep from getting too deep underground. If care is taken to see that the pipe is properly supported so that the grade is uniform, it is seldom necessary to grade more than 12 in. in 100 ft.

In a job of this kind ample insulation (3 to 4 in.), by maintaining even temperatures, will greatly reduce maintenance of the line. Steam should not be turned on and off any more than absolutely necessary, as each change in temperature racks the joints just so much and eventually causes leaks. For steam conditions such as described, the only safe joints, unless the pipe can be placed in a tunnel where everything is accessible, are welded joints, because no matter how carefully flanged or screwed joints are made up, it is only a matter of time until some of them leak and the whole line has to be dug up.

New Haven, Conn. H. D. FISHER.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

Staying Put

Every man is a merchant. He has something to sell. It may be food, furniture or Fords; or it may be knowledge, strength, experience or skill. And just as it costs the retail-merchant a great deal of money and trade prestige to move, so it costs the industrial-worker-merchant a great deal of money and prestige to change positions.

A retail merchant who remains in one location over a period of years builds a good trade. In like measure, the industrial-merchant who stays with one firm a long time builds for himself a value possible in no other way.

Shifting from one job to another costs more than money. It costs time and prestige. As for the financial side of it, however, a man who changes jobs for a $10.00 monthly increase in salary, really makes nothing by the change for the first year.

No set of figures can be made that will cover all cases, but the tabulation of a few of the major items serves to bring out the point.

Moving expenses	$ 25.00
One week's time in making change	50.00
Increased house rent at $5	60.00
Lowered production for 3 weeks in getting adjusted to new work	25.00
	$160.00

Putting an "ST" in front of inherent Ability, thereby making it STA-bility is a worth while action too frequently overlooked.

One Reason for Our Multiplicity of Laws

For a great many years thoughtful citizens have recognized the demoralizing effect of hasty legislation on the Constitution of the United States. Fear, in this regard, was expressed by Abraham Lincoln. Even John Marshall warned us against "the hasty passage of unsound statutes."

That there is a definite trend for the complete destruction of that document, too few of us realize. It has existed in traceable form for over 35 yr. The first visible action started in California, about 26 yr. ago, with agitation for the Initiative Referendum and Recall. While we have no intention to argue the merits of these measures, whatever may be said in favor of the Initiative, Referendum and Recall, it is undeniable that they are at vital variance with the constitution.

The second blow at the constitution was struck in 1913 when the eleetion of U. S. Senators was delegated to the direct action of the open primaries. Certain senators are now proposing the abolition of the electoral college which would throw the election of the president and vice-president into the open polls. This is the third blow at the constitution. The systematic attacks now being made against the Supreme Court constitute the fourth blow.

Federal, state and municipal laws and ordinances now total in excess of two million. To perform his duty successfully, a policeman in New York City must have knowledge of over 16,000 laws. State legislatures and congress grind out more than 2000 new laws every year, and nearly 20,000 more are annually enacted by municipalities and county boards. Of course we have need for new laws. This country is changing constantly by reason of its progress. Without adequate governmental measures our progress would be stifled. But we don't need 20,000 new laws a year—nor yet 2000. Certainly, we have no need for more constitutional amendments. Contempt for government and disregard for all law is the natural result of confusion and contradiction in statutes.

There is a solution for this destructive movement. The solution is in five parts and is: 1. Compelling public officials to regard their oath to support, maintain and defend the constitution as obligatory in letter and spirit. 2. Requiring all schools and colleges to teach properly American principles and ideals, so that patriotism may be fostered among school children and the true spirit of America may be created for the upbuilding of American citizenship. 3. Strict enforcement of every law against sedition and holding to legal accountability every individual or organization advocating measures detrimental to the principles of this government. 4. A national campaign of education to revive and stimulate confidence in our Federal Government. 5. Opposition to all organizations or individuals holding subversive motives, to the end that loyalty to the constitution and the flag may not be undermined.

Safer to Fly Than to Ride?

Although the figures are not yet completed for the year 1924, Frank F. Rogers, president of the American Association of State Highway Officials, believes the following totals to be fairly accurate: 22,500 women and children were killed by automobiles last year, and over 675,000 serious injuries to men, women and children, were inflicted by accidents while driving.

Sombre as these figures are, they form the basis for an interesting comparison between the accident frequency of aviation and motoring.

During 1924, the subsidized civil aviation firms in England reported 4033 flights. Of this number, 351 flights, or 9 per cent, were interrupted. Weather conditions were responsible for considerably more than half of the forced landings, although 91, or 26 per cent of the stoppages, were caused by engine trouble. In only three cases of the 351 forced landings did injury result to the machines, and in no case was there a fatal or serious injury. Indeed, with the exception of one fatal accident reported from an established mail-route, no person carried in airplanes registered in the British Isles, and flying for hire or reward, was injured to any serious extent during 1924.

Blowing Snow From Railroad Tracks

Outstanding among recent mechanical developments is the new device, now being tried out on the Pennsylvania Railroad, which, if successful, dooms all present day snow plows and shovels. The new device is one that blows hot steam in front of a locomotive, melting and clearing all snow from the railroad tracks in much less time and in much more efficient manner than is possible under the old snow plow method.

Particularly efficient is the new snow remover for switches, crossovers, frogs, signal plants, etc., as it completely eliminates the hand work that is now necessary in clearing snow from such places.

Trend in Passenger Transportation

Privately owned automobiles and motor busses have effected a decrease of 2,242,640 passenger train miles on the New York Central Railroad alone, in the last 6 yr.

Pinehurst, a nationally known resort, reports that during the past year only one in every four guests arrived by rail, 75 per cent coming by automobile.

Choosing at random three trips, on three different railroads, and comparing the ticket sales of each, it was found that less than 200,000 tickets were sold for those trips in 1924, as against 369,500 in 1916.

Commercial travelers "making" the small country towns can no longer use the railroads for transportation. Each salesman must equip himself with an automobile or he cannot survive competition.

Since January 1, 1924, over 1500 new bus lines, operating nearly 6000 busses, have been established. The investment in the new lines is approximately 30 millions of dollars.

U. S. A.

According to A. A. Beckwith, technical and industrial research expert in New York City, in Australia the following wage scales are standard:

Locomotive engineers	$35 weekly (maximum)
Blacksmiths	27 weekly (maximum)
Linotype operators	29 weekly (maximum)
Motormen	25 weekly (maximum)
Street-car conductors	24 weekly (maximum)

In Sweden:

Machinists	20 weekly (maximum)
Miners	18 weekly (maximum)
Railroad workers	15 weekly (maximum)

Other foreign countries range downward in wage scales, according to their economic status. For instance, the average daily wage (November, 1924) in England was $2.28; in Germany, $1.55; France, $1.30; Belgium, $1.15; Italy, 96c— and in the United States, $5.60.

Even considering the difference in cost of living, the American worker is far ahead of his European brother. The average American has in his home, hot and cold water, bath rooms, gas stoves, electric lights, telephones, phonographs, pianos; whereas a large percentage of workers in foreign lands consider those things luxuries of the rich.

Add to these facts the simple truth that anyone, regardless of station, can, by diligent effort and intelligent application, reach the top of the commercial ladder, and you find the basic reason for America's greatness.

Remarkable Progress in Reconstruction

In the devastated regions of France it was estimated that 893,792 of the original 1,190,066 buildings, were either completely destroyed or damaged beyond use. Of the number of buildings damaged or destroyed, 80 per cent of the houses and 88 per cent of the factories have been rebuilt and put into operation. Ninety per cent of the damaged canals have been reconstructed and over 80 per cent of the trenches used by both armies have been filled in. These percentages are calculated up to August 1, 1924. It is estimated that the work of reconstruction, if continued at the present rate, will be largely completed by January 1, 1926.

The pre-war population of the war affected areas was about four and one-half millions. At the time of the last census, January 1, 1924, the number that had returned permanently to the devasted regions totalled 4,250,000.

Through the Credit National, an agency set up by the French Government for the purpose of compensating those suffering physical loss or damage from the war, more than sixty billion francs have been paid claimants, an indebtedness to sufferers of approximately twenty billion francs remaining. The compensation so distributed was made partly in cash, a portion in material, and the balance in government securities.

Developing Cleaner Motion Pictures

George Beban, motion picture star and producer, was one of the first to recognize the demoralizing influence sex appeal and general salaciousness would have on the motion picture industry. He foresaw the day when this characteristic, if allowed to continue unabated, would kill the industry, just as meddling in politics killed the liquor industry and the bribing of jockeys almost ruined horse racing. George Beban is devoting his energies and staking his entire fortune on the development of clean pictures.

He recently appeared in Chicago in "The Greatest Love of All," presenting one scene of the play in person. During his Chicago visit, Mrs. Sibley and the writer had the pleasure of an hour's chat with Mr. Beban. Being interested in his campaign for cleaner pictures we asked a few questions. These questions, with Mr. Beban's replies, are here given because they shed an interesting light on the changing American tastes.

Q. What is your definition of a "clean" picture?

A. One in which there appears no salaciousness.

Q. What has been your experience, from the box office receipt standpoint, with clean pictures?

A. Three or four years ago every picture I produced operated at a loss. Today the receipts are much better. We hope for the morrow.

Q. To what do you attribute this change?

A. Education of the public and the introduction of better acting in clean pictures. Formerly, most of the good actors were playing questionable themes.

Q. A few years ago "Passion" was a popular film. What would have been the effect had that film been titled "The French Revolution" instead of "Passion"?

A. Had "Passion" been called "The French Revolution" four years ago it would have lost money for its producers. At that time suggestive titles or sex appeal was imperative for success. Today "The French Revolution" would get by all right. We hope that in four years from now the conditions existing four years ago will have reversed themselves.

Q. Isn't it true the great majority of Hollywood people are honest, sincere, hard-working folks—that it is only the rotten eggs that come to our attention?

A. Boy—you said it!

EDITORIAL COMMENT

Heating and Ventilation of Power Stations

Progress in any art brings forth new problems. A few years ago in the design and construction of steam power plants little or no attention was paid to the matter of heating the buildings. The natural radiation of heat from the steam using and power producing equipment as a rule was sufficient to satisfy all ordinary heat requirements and no special provision for heating was made. In the boiler room particularly, the amount of heat radiated was so great that even on cold winter days there was more discomfort from too much heat rather than from a lack of it. This condition was so general that today the very thought of installed special heating equipment in the boiler room seems ridiculous, or at least somewhat of a novelty.

As a matter of fact, however, heating equipment is an absolute necessity in the modern power station, not only in the turbine room but in the boiler room as well. Modern power producing equipment has been developed to such an extent that heat radiation from its surfaces is insufficient to satisfy heating requirements and it has become necessary to install heating systems.

This requirement has brought with it some interesting problems. For instance, where shall the steam for the heating system be obtained, and how shall the supply be controlled? If reducing valves are to be used, what principles shall be employed in their design? If steam is to be desuperheated, what methods shall be employed? How shall the switch house and the electrical bays be heated?

Similar considerations have to be taken into account with regard to ventilation of the power station. In the early days of power generation, when machines were of small size, no special ventilating arrangements were needed. Natural ventilation was all that was required. Today, with the use of high capacity forced draft furnaces, and electrical apparatus requiring artificial cooling the quantities of air handled are enormous and elaborate ventilating systems are required, not only for the machines themselves but for general ventilating purposes as well. In some cases, such as in the storage battery room, special precautions have to be taken to prevent corrosion of the fans and ducts due to the sulphuric acid fumes.

In view of these facts, we are presenting in this issue an article which describes the heating and ventilating system installed in the new Weymouth Station of the Boston Edison System. This is a steam-driven station of the most modern design and the heating and ventilating requirements there are typical of what may be found in other central stations throughout the country.

Practical Application of Exact Data

One criticism the practical man often makes of exact engineering data and formulas is that they are too exact and therefore not applicable to practical work. At a recent engineering gathering, in discussing the effects of temperature upon the friction of water in pipes, it was asserted by one member that while the formulas available for predetermining the friction were without doubt correct, they could not be used in practice because it was impossible to estimate beforehand, with any degree of certainty the exact number of elbows, bends and joints in a particular piping system. Notwithstanding the accuracy and care used in preparing the original drawings and specifications, unforeseen conditions during construction usually made the completed job somewhat different from that first planned in the drafting room, that is, insofar as the total number of fittings were concerned. The speaker, therefore, encouraged the use of large factors of safety so as always to be on the safe side.

Factors of safety, we agree, are necessary in any kind of engineering work and their value must not be underestimated; nevertheless, it must be pointed out that the criticism referred to above is wrongly directed. The trouble lies not in the shortcomings of exact engineering data but rather in the limitations and inaccuracy of practical methods: The engineer or scientist who derives the formulas and brings forth new laws cannot be held responsible for the shortcomings of practical methods. It is his business to present the facts but it is the practical man's business to apply these facts to his own advantage. The closer he can approach the facts the more accurate will be his work. The research engineer evolves the formulas; it is up to the practical man to substitute the correct figures in the formulas. If he does this his work will coincide with theory.

It is realized, of course, that there are difficulties and that as the speaker referred to stated, it is not always possible to predict or to plan exact conditions. He can, however, always keep in mind that the data of the authorities can be accepted, if he applies it in a sufficiently accurate manner.

Steam Table Research Workers Report Progress

For some time, considerable research work has been going on for the purpose of correcting the steam tables. In cooperation with the A. S. M. E., research workers at the Bureau of Standards, Harvard University and Massachusetts Institute of Technology have been developing methods and apparatus for determining the relations between heat content, entropy and the steam table values under various conditions. The latest reports state that the experimental work at Harvard is completed, on account of the fact that the apparatus for measuring the Joule-Thomson effect was ready some time ago. At the other two laboratories, apparatus for the tests had to be developed; it will be some time before the tests are completed.

When it is considered that various experimenters on the steam tables give results varying in some cases by as much as 10 per cent, the importance of an accurate determination is seen. There are, of course, many cases in practical work in which we desire accuracy to within at least 2 or 3 per cent, so that this question of a correct steam table is not at all a purely theoretical one.

It is not an easy matter to obtain these true values. Great care must be used in all measurements and the experimenters have rightly taken the attitude that the best way to attain the desired result is by thorough preparation, anticipating obstacles or overcoming them in the preliminary work, and thus avoiding puzzling discrepancies which might require further experiments to interpret.

To show the care with which apparatus for these tests is constructed, it is interesting to note that a highly skilled instrument maker at the Bureau of Standards has been at work for two years on the calorimeter that is to be used. In this instrument of high precision, certain parts are of silver, gold and metals of the platinum group, as the instrument must be not only a delicate piece of mechanism but also a sturdy one. Only the finest workmanship will suffice in making such an instrument.

This thorough investigation of the steam tables is one of the most important ever undertaken by any organization. These tables, together with the Mollier diagram, are probably the most useful tool the steam engineer has to work with. The various research workers are to be complimented on the care they are taking to secure correct results; every step taken so far points to a successful conclusion. Without disparaging the work of the able men who have laid the foundations, it is to be hoped that the result of this experimentation will be a steam table of such accuracy that it can be accepted as the best it is possible to obtain by modern scientific methods.

Checking Up on the Cause of Waste

It is extremely questionable whether or not engineers, as a whole, stop to view their problems in the light of the business problems of the nation. After all, however, it seems entirely reasonable that not only do the problems of waste elimination in the power production field closely parallel those of the nation's business, but also that the methods employed of attacking the problems of national waste in business can be applied successfully within the engineers' field. In other words, power production is a national business just as much as is the merchandizing of a manufactured product; therefore, the principles governing economical production and distribution and the elimination of waste can be applied equally well in either case.

At a recent conference called at Washington by the Chamber of Commerce of the United States, Mr. Hoover spoke on the problems of distribution. Among other things, he outlined the kinds of waste which result in the most costly losses in our national business system. For instance, he mentioned that speculation, the relaxation of effort and excessive seasonal character of production and distribution were all causes which contribute to waste. Consider them for a moment from the angle of the power production problem. Speculation is seldom based on sufficient facts so that both price and usage will be advantageous to the purchaser of supplies and equipment. Relaxation of effort is absolutely ruinous, because it not only stops progress from being made, but it allows the whole organization to lose ground and revert back to unsatisfactory conditions of operation. Wastes from excessive seasonal character of productions and distribution are at once apparent in both the supply of fuel for power and also in the character of the demand for power.

Other causes of national waste which were emphasized at that conference and which are equally applicable to power production, are those due to lack of information regarding production and consumption; lack of standards of quality and grades; a lack of uniformity of business practices in terms and documents with resultant disputes, misunderstandings and frauds; deterioration of commodities is still another cause, as are also inadequate transportation and handling facilities and wastes in the use of materials.

These wastes were outlined at a conference of the nation's business men and as is seen they are also applicable to power production which is one of the big units of our national business. It can, therefore, readily be appreciated that the causes of waste should be given careful consideration by all of those responsible for that most essential commodity of our present day industrial development.

Three-Fold Responsibility of the Fireman

One of the most favorable indications of progress in modern industrial plant operation is the increasing interest that is being taken in the work of the fireman and in boiler house operation. We should never lose sight of the fact that economy in burning coal is now, always has been, and probably always will be determined by the efficiency of the men on the firing floor.

Installation of various labor-saving devices, such as coal- and ash-handling machinery, gages, meters of various kinds, automatic combustion control devices, are not intended to replace the fireman. They are installed rather to help him. The stoker is nothing more than a conveyor for putting large amounts of coal into the furnace. Various forms of draft control are intended to make for the fireman as many of the adjustments as possible, thus leaving him more time to study and regulate the condition of his fire.

We are calling upon this fireman to perform three things: First, he must at times perform ordinary manual labor, not as hard as it used to be, it is true, but still hard enough. Second, the process of burning coal is primarily a chemical process, and a comparatively delicate one, too. To secure in the furnace the proper amounts of coal and air and the proper ratio between these amounts for variations in load, is not an easy matter. Third, careful records should be kept of boiler performance and the fireman must do considerable bookkeeping.

This modern fireman, a combination of workman, chemist and bookkeeper, is one of the most important figures in the modern plant. Through his hands passes all the coal, the cost of which forms the greater part of the power cost. To help him discharge his three-fold responsibility, first, by installing labor-saving and control devices and second, by showing him that successful operation of this equipment depends entirely on the brains behind it, is an important duty of every engineer. Such an attitude will always be repaid by economy in the production of power.

Diesel Engine Automatically Lubricated

NEW SOLID INJECTION DIESEL ENGINE HAS MANY FEATURES CONTRIBUTING TO SIMPLICITY, ACCESSIBILITY AND LOW MAINTENANCE COSTS

ELIMINATION OF ignition devices, automatic lubrication, simplification of the fuel injection system and changes in the air scavenging and water-cooling arrangements are some of the features of the Diesel engine which has recently been brought out by Fairbanks, Morse & Co., of Chicago. The former type "Y" engine was what might be classed as a moderate compression Diesel; that is, a heating torch was required for starting although after it

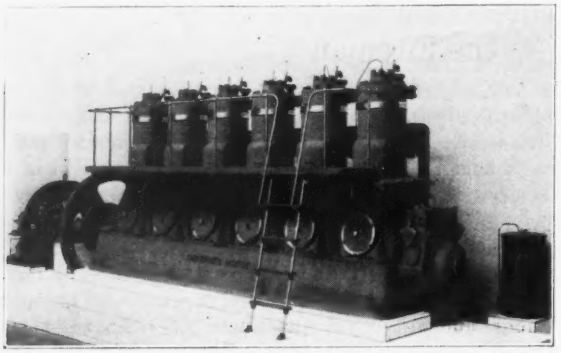


FIG. 1. RATING OF THE SIX-CYLINDER ENGINE IS 600 HP.

was under way it fired by the heat of compression and not by contact with a hot surface. In the new design the compression has been raised to 500 lb. and the engine starts cold.

Although the new engine is not a radical departure from the former type "Y" engine it is a logical evolution, advantage having been taken to incorporate many improvements in details. Piping has been eliminated or enclosed, the control has been simplified and what few adjustments there are have been made more accessible.

The mechanical lubricator is located at the end of the engine just above the governor and fuel injection control unit. It is driven from an eccentric on the crankshaft by means of a rocker arm and ratchet type of drive. Oil is forced to the cylinder, piston pin and crankpin by the forced feed lubricator. From these bearings the surplus finds its way to the lower crank case from which it is drained into a sump or well. The dirty oil is then pumped to an oil filter and after being cleaned is fed into a sump chamber, from which it is again pumped to the lubricator.

It will be noted that the main bearings are ring oiling, with oil wells in the lower base. The governor and related parts are supplied by splash lubrication in the governor housing. Surplus oil which is pumped to the lubricator by the clean oil sump pump overflows and is carried down over the eccentric and collects in the extension of the lower base that supports the injection pump and governor housing. The governor, dipping in the well thus formed, keeps the pump cam, pump rocker and rollers covered with oil.

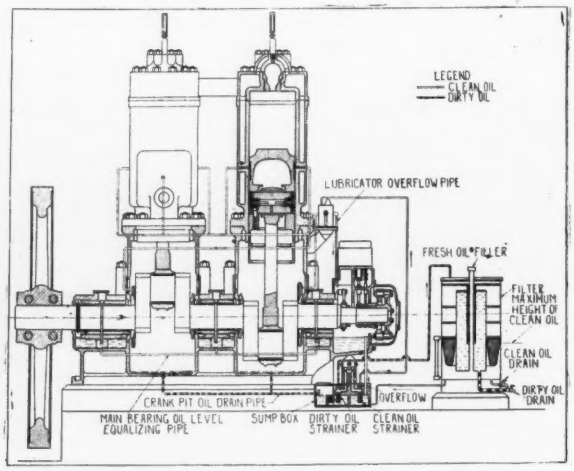


FIG. 2. OIL DRAINS TO CRANK CASE AND IS PUMPED TO A FILTER BEFORE BEING RECIRCULATED

This well is interconnected with the main bearing oil wells and is provided with an overflow that maintains a constant level of oil throughout the system.

Used oil from the crank case is drained into a sump from which the used oil pump draws it to the filter. In addition to being connected with the overflow of the oil wells the suction of the clean oil pump is connected to the clean oil compartment of the filter and when the oil in the interconnected wells of the main bearings has been used to such an extent that the level of the oil drops below the overflow the clean oil pump takes its suction from the clean oil compartment of the filter and builds up a supply of oil to the height of the overflow. As this level is higher than that of the filter, further suction from the filter is then automatically cut off.

LUBRICATION OF THE CYLINDER

There are four feeds from the lubricator to each cylinder. One leads to the side of the cylinder nearest the governor and lubricates the piston pin; one leads to the front side of the cylinder and another leads to the opposite governor side of the cylinder and both of these lubricate the piston. The fourth feed leads to the upper base and lubricates the crankpin bearing.

Another important change which has been made in the design has been in the raising of the compression pressure to 500 lb., so that the increased heat due to this compression fires the fuel without the aid of a torch when starting. An auxiliary combustion chamber is provided into which the air rushes on the compression stroke and meets the atomized spray from the injection nozzle. The turbulence caused by this meeting of the air and fuel aids in preparing the fuel for complete combustion and also holds the charge in suspension.

When the piston reaches the end of its stroke, the temperature of the fuel charge in the auxiliary combustion chamber is raised to the ignition point and combustion begins. The hot gases then expand through the neck of the chamber and combustion is completed in the cylinder. Fuel injection is practically the same as in the former design with the exception that the pumps are grouped on a

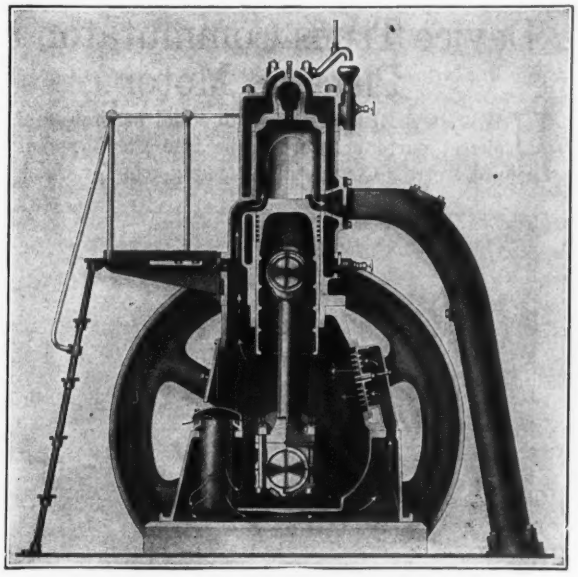


FIG. 3. SIMPLICITY IS A FEATURE OF THE TWO-CYCLE SOLID INJECTION DIESEL ENGINE

pump deck and enclosed in a case which serves as the fuel oil reservoir.

This fuel system consists of a single plunger pump for each cylinder and one auxiliary plunger pump which draws the fuel from the auxiliary supply tank and which then pumps it into the reservoir in which the injection pumps are submerged. The auxiliary fuel pump is operated by a rocker arm which is connected to an eccentric on the main engine shaft. All of the fuel injection pumps are operated through a single cam on the governor shaft, through a simple bell crank. Each of the plunger pumps has a constant stroke with a displacement in excess of that required for maximum load. Each pump also has a separate suction valve which is operated by a rocker actuated by another cam on the governor shaft.

When the fuel injection pump plunger begins to rise, due to the rotation of the cam, the fuel oil flows out through the open suction valve and out through the auxiliary fuel reservoir. As the main shaft continues to rotate, the cam, which operates the suction valve, reaches a point where it has a depression in its face and the suction valve closes. The pressure in the fuel injection pump cylinder begins to rise and overcomes the spring loaded discharge valve and the fuel oil passes to the fuel oil nozzle. When the pressure has reached a point sufficient to overcome the resistance of the spring in the injection nozzle, injection begins. Just before the engine reaches the point in its stroke where the fuel injection is to be cut off, the power plunger opens a relief valve and the pressure in the fuel line immediately drops to zero, thus providing for a sharp cutoff of the injection.

Timing May Readily Be Changed

It is possible to regulate the timing of the fuel injection by changing the angular position of the cam which

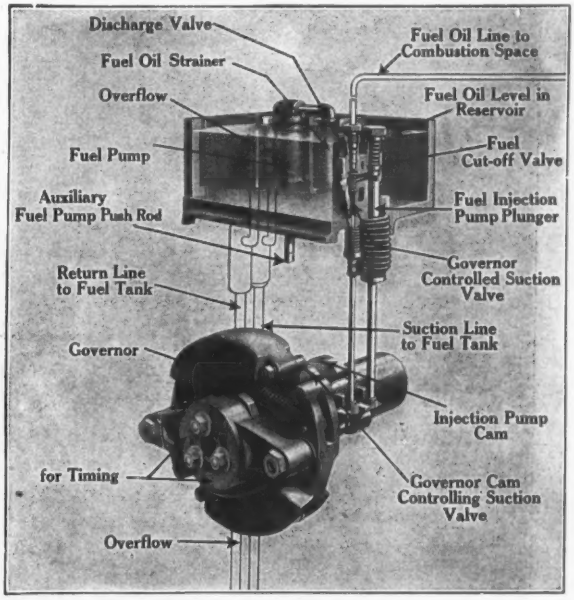


FIG. 4. ARRANGEMENT OF THE INJECTION PUMP DRIVE

operates the injection pumps. This adjustment is made by loosening three nuts and rotating the governor spider. The cam which operates the suction valve is loose on the shaft and is connected to the governor mechanism through links. Since the amount of fuel which is injected by the fuel pump is determined by the time of closing of the suction valve, it can be seen that this is under the control of the governor. If the load on the engine is heavy and the speed starts to drop slightly, the governor adjusts the position of this cam so that the suction valve closes earlier, hence more fuel oil is trapped in the pump cylinder and pumped to the fuel injection nozzle.

Starting is accomplished by means of compressed air. This air is stored by an auxiliary power compressor, in steel tanks of sufficient capacity for several starts. The pressure used for starting is approximately 200 lb.

In addition to the two cams on the governor shaft which operate the fuel injection valves and the suction valves, another cam controls the admission of the air for starting.

From the timed valves, the air flows into the cylinders through pipes and air check valves on the cylinder heads. For the control of the starting air, a single lever, properly marked for the starting and running position, is used. The air valves are so interlocked with the hand lever that safe and dependable starting is assured. The fuel control lever operates a control shaft having two cams; one of these serves to prime the fuel pumps for starting, the other to

shut down the engines by holding the fuel pump suction valves open.

Improvement in Ejecting Burned Gases

Another important point in Diesel engine design is in the arrangements which are provided to eject the burned gases at the end of the expansion stroke. One of the improvements which has been made in the new design is that this scavenging air is transferred from the crankcase to the cylinder through a passage outside the water jacket,

FIG. 1. THE LEONARD-MORROW COMMUTATOR TURNING TOOL MOUNTED ON MOTOR READY FOR USE

thereby eliminating the necessity for air ports in the pistons and allowing the cylinder to be completely water-jacketed for its entire length.

Before the opening of the air inlet or scavenging ports, which occurs shortly after the opening of the exhaust ports, the exhaust pressure drops to virtually atmospheric pressure. The air which has been compressed to a low pressure in the crankcase enters the cylinder when the scavenging ports are uncovered and is deflected by the piston to the upper portion of the cylinder, clearing out the remaining burned gases and charging the cylinder with fresh air.

This scavenging air is supplied by the piston and crankcase acting as a pump. Upon the upstroke of the piston, air is drawn through a screen and automatic air valve, into the crankcase and is compressed upon the working or downstroke as previously mentioned.

Cooling water is introduced into the jacket of the head. The whole jacket has a practically uniform temperature. The ridges of the cylinder ports are also cored for water passages and are thus kept at a uniform temperature. At the cooling water outlet, at the top of the cylinder head a spout is provided that discharges into a water header. This arrangement gives a visual check upon the water circulation. Where the cooling water supply is limited and a recirculation system is necessary, a closed connection from the cylinder head is used. In either case thermometers are provided for checking the cooling water temperature.

At the present time the engine is built in ratings of 37½ and 50 hp. for the single cylinder unit; 75 and 100 hp. in two cylinders; 150 hp. in three cylinders; 200 hp. in four cylinders and 300 hp. in six cylinders.

In bringing out the new design, the primary consideration has been to develop an engine with low maintenance costs, maximum accessibility and simplicity of operation. Fuel economy was also carefully considered, although no sacrifices were made in ultimate performance to secure the lowest possible test consumption of fuel. The tests which have been conducted show a fuel consumption of 0.42 lb. of 18,000 B.t.u. fuel oil per brake horsepower hour at full rated load.

Device Trues Commutator in Place on Motor

USERS OF ELECTRIC motors and generators of the direct current type will be interested in the new Leonard-Morrow Commutator turning tool for which the

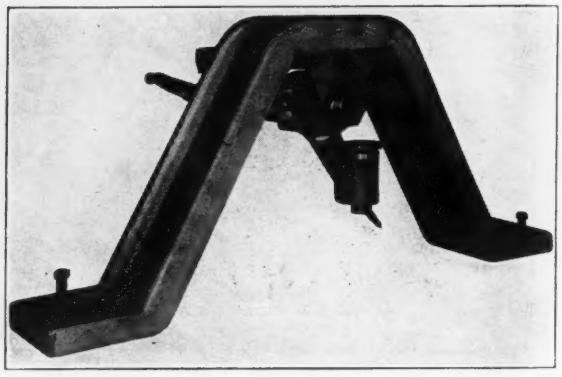


FIG. 2. ASSEMBLY OF THE TURNING TOOL TOGETHER WITH BRACKET

Green Equipment Corporation of Chicago are the exclusive distributors. This device is designed for the purpose of truing the commutators of generators and motors in place without removing the armature from the bearings. Its use, therefore, does away with the dismantling of the motor and the removal of the armature, thus effecting a considerable saving in time.

As may be seen from the photographs, the device consists of a mounting bracket which carries the turning tool. A crank is provided for rotating the armature by hand although if desired, the armature may be rotated, under its own power.

The device is made applicable for use on different types and styles of machines by the provision of a number of different size mounting brackets. It is rigid in construction, accurately finished and is simple and positive in operation. It is particularly applicable for use in connection with elevator motors which do not permit of being taken out of service for any great length of time, as the commutator can be trued up after working hours or on Sunday, without risk of gouging or damaging it in any way.

Automatic Cellar Drainer Operates on Water Pressure

SPECIAL FEATURES of the new model "R" automatic cellar drainer, as made by the Penberthy Injector Co., Detroit, Mich., are that the ejector jets are removable, the valves are of bronze, the seats are beveled to give long wear and the ejector is placed below the water level, thus all suction and priming troubles are eliminated. Further, the unit is compact and requires a minimum of floor space; the rotary valve reduces stem packing friction troubles; the closing of the valve is positive, avoiding waste of pressure water and still not producing water-hammer. The patented lever and link actions, which are adjustable to different water pressures, allow the float to be nearly submerged before the valve opens, thus giving a quick action to the opening of the valve and avoiding dead center troubles.

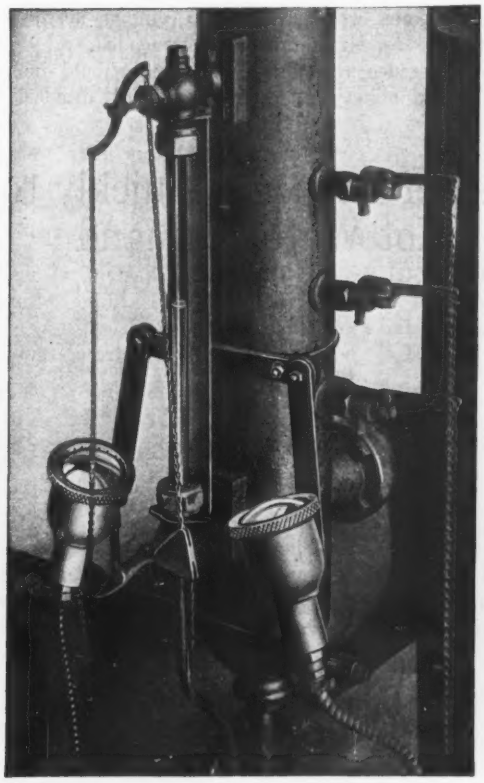
This cellar drainer is intended to be installed in a sump below the level of the surface to be drained. The drainer valve is normally in a closed position. As the water rises in the sump, it lifts the float until when sufficient water has accumulated, the float buoyance opens the valve and starts the ejector. The ejector pumps rapidly, until the level of the water in the sump has lowered to a point where the float in descending with the level of sump water automatically closes the valve. The cellar drainer then remains inactive, using no pressure water, until the sump has again filled with seepage water.

FIG. 1. ALL WORKING PARTS ARE LOCATED ABOVE THE MAXIMUM WATER LEVEL. FIG. 2. SHOWING LOCATION AND METHOD OF PIPING THE DRAINER

Water Column Illuminator

ILLUMINATION OF the boiler water glass by two directed light sources and the total reflection of the directed light beam by the meniscus at the water level are the principles upon which the National Co., Boston, Mass., has designed its water column illuminator. This device consists essentially of an aluminum bracket, a steel yoke, two adjustable steel arms and two aluminum lamp housings. The yoke and bracket, which carry the adjustable arms, are secured directly to the body of the water column. On the free end of each arm is mounted a lamp housing which is equipped with a lens so the light from the 50-w. Mazda lamps will be directed to the center line of the water glass.

Viewed from the front, each lamp is mounted so that its center line makes an angle of about 30 deg. with respect to the center line of the gage glass. Viewed from the side, the lamps are placed at an angle of about 15 deg. with respect to the water glass. Provision is made by means of a number of openings in the housing so that an air connection may be used to blow off the dust which may collect on the lenses. An advantage claimed for this illuminator is that by its use the water level in the gage glass is distinctly visible from all parts of the operating aisle.



TWO BEAMS OF LIGHT ARE DIRECTED ON THE WATER GLASS

Overhead Line Materials

REPRESENTATIVES of 19 interested organizations held a conference on the unification of overhead line materials at the Engineering Societies Building, New York, on January 13. The conference recommended by unanimous action that an extensive program on the unification of overhead line materials go forward, under the procedure of the American Engineering Standards Committee. It was decided that the work should include cross arms, pins, pole steps, brackets and moulding; pole line hardware, including such items as anchor rods, bolts and lag screws, brackets, cross arm braces, guy fittings, pins and strand for suspension and guying; and strain insulators, spools, knobs, etc.

After an extended discussion as to whether work on insulations should be limited to low voltage material, a small committee which was appointed reported the following recommendations, which were unanimously approved:

"Certain classes of insulators have reached a stage of development which seems to warrant standardization; others can be standardized as to certain important dimensions; still others are in a development stage which makes attempted standardization, other than along the broadest of lines, of questionable wisdom.

"It is recommended that standardization in this general field be undertaken to such an extent as the facts developed by a sub-committee, or such other agency assigned to this work, may seem to warrant.

"Of the other types, strain insulators for low potentials, spools, knobs, etc., which are used in common by the several branches, standardization is recommended."

The conference agreed that the work should include nomenclature, material specifications, and dimensional data.

Heater Responds Quickly to Hot Water Demand

MARION GULF STREAM water heaters, as manufactured by the Marion Machine, Foundry & Supply Co., Marion, Ind., are made of semi-steel castings, outer casing being steel and the inner chambers are of standard

FIG. 1. SECTION THROUGH THE HEATER

water pipe or copper tubes, either of which are so arranged that expansion and contraction is taken care of by stuffing boxes at each end of the heater. The heads are divided by an extra flange to which is attached the large

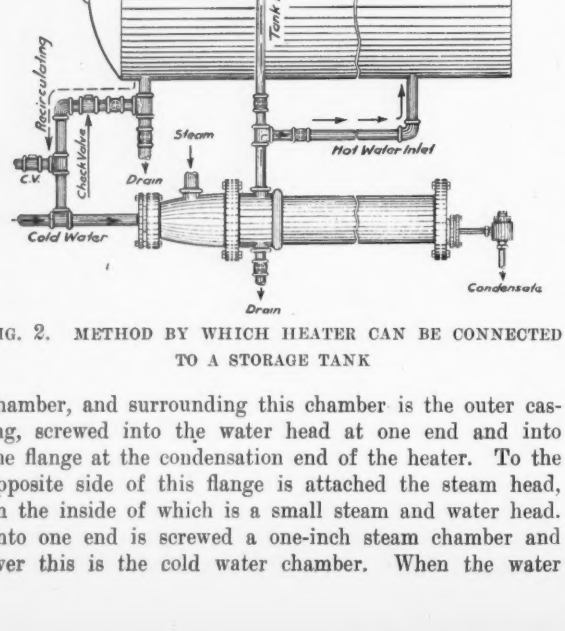
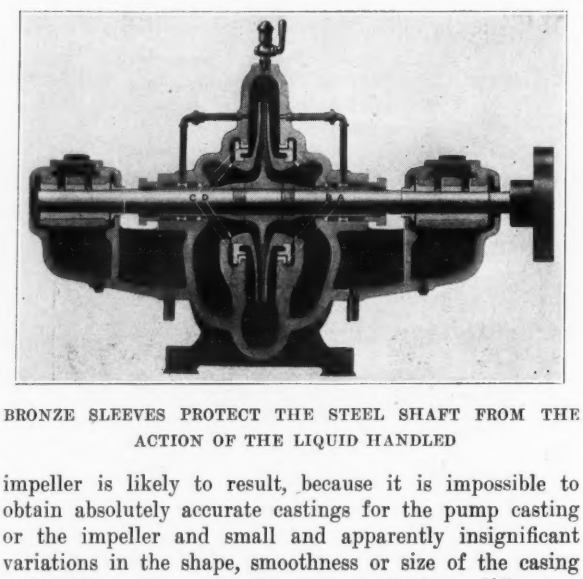


FIG. 2. METHOD BY WHICH HEATER CAN BE CONNECTED TO A STORAGE TANK

chamber, and surrounding this chamber is the outer casing, screwed into the water head at one end and into the flange at the condensation end of the heater. To the opposite side of this flange is attached the steam head, on the inside of which is a small steam and water head. Into one end is screwed a one-inch steam chamber and over this is the cold water chamber. When the water enters, it is immediately broken into a thin sheet, having steam on the inside and outside and is compelled to travel in a spiral course to the outer end of the heater, where it empties into the 6-in. casing to be returned in a spiral course again over the 4½-in. steam chamber to the hot water outlet. The escape of condensate is provided for by the ¾-in. brass pipe through the rear flange and stuffing-box. The temperature of the water is controlled by a thermostat so that only enough steam is used to keep the water at the specified temperature. These heaters can be obtained in three sizes with either steel or copper tubes and for steam pressures up to 15 lb.

Hydraulic Balance Obtained in Double Suction Pump

THEORETICALLY, a double suction pump, if properly designed, has no end thrust, but it is a well known fact that end thrust or unbalanced pressure on the sides of the



BRONZE SLEEVES PROTECT THE STEEL SHAFT FROM THE ACTION OF THE LIQUID HANDLED

impeller is likely to result, because it is impossible to obtain absolutely accurate castings for the pump casting or the impeller and small and apparently insignificant variations in the shape, smoothness or size of the casing or impeller water spaces give rise to quite large differences of pressure on the sides of the impeller.

Unbalanced end thrust is eliminated in pumps manufactured by The Earle Gear & Machine Co., Philadelphia, Pa. by a device shown in the sectional view of a type "B" DSV pump. If the thrust is towards the reader's right, the radial seat at "B" will tend to close, while the radial seat at "A" is opened, building up a pressure on the total area of the right side of the impeller. While this is occurring, the radial seat at "C" has closed, and the radial seat at "D" has opened, placing a suction or reduced pressure on the area of the side of the impeller from "C" to the shaft. Hence, the area on the right side of the impeller, subject to high pressure, is greater than the area of the left side of the impeller from "C" to the shaft; the pump rotor will tend to move slightly to the left until it reaches a point at which the total pressure will be the same on both sides of the impeller and true hydraulic balance is obtained. The opposite cycle of events takes place if the original thrust tends to be towards the reader's left.

Due to this hydraulic balance, no thrust bearing or collars are required; but since any device must ultimately

wear out and being inside the case where wear is not visible, small fixed collars are placed on the shaft, set at a distance from the face of the bearing bushing, which will not become operative until the limit of allowable wear has occurred within the case, at which time the engagement of the collars and bearings becomes a visible indication of the need of replacement of wearing parts within the pump.

These pumps are also designed with split babbited bearing shells with two oil rings. Bronze sleeves are provided to protect the forged steel shaft from the action of the liquid handled; deep stuffing boxes with a brass stuffing box bottom, ring, and brass water seal rings are incorporated in their design, and provisions are taken to keep the oil from splashing out of and from water entering into the bearings. Provisions are also made to minimize the air pockets in the pump casing and to keep the water from rotating with the impeller in the suction passages, thereby increasing the efficiency.

New Test Code for Steam Boilers

IN THE THIRTY-EIGHT YEARS that have elapsed since the adoption of the original A. S. M. E. Code for the testing of steam boilers it has undergone several revisions made necessary by the progress of the art. Such a revision has just been completed and the code is now available in the thoroughly up-to-date form in which it has been adopted by the Council of the A. S. M. E. as the approved standard practice of the profession.

The committee in charge of this 1923 revision consists of Edwards R. Fish, vice-president, Heine Boiler Co., chairman; Arthur D. Pratt, Babcock & Wilcox Co., secretary; Alex D. Bailey, superintendent of generating stations, Commonwealth Edison Co., Chicago; Albert A. Cary, consulting engineer, New York; and Edwin B. Ricketts, assistant to chief operating engineer, New York Edison Co.

In the 1915 draft, the code for stationary steam boilers related primarily to tests made with coal, while the latest (1923) revision covers in a complete way tests with solid, liquid and gaseous fuels. The use of each of these types of fuel is treated when stokers, superheaters, economizers and air preheaters are attached to the boiler.

Complete revision of the text of the code has been made and the Data and Results section has been developed in an entirely new form. It now contains separate tables for each combination of apparatus, each item of which is covered by an item in a corresponding section devoted to computations. As a result of this arrangement considerable time will be saved in computing tests made according to this standard code. To facilitate further the computations and record of stationary steam boiler tests, the A. S. M. E. is planning to issue in separate pad form the various data, heat balance and computation sections.

New Plant for Kansas Power & Light Co.

AT A POINT about 7 mi. east of Topeka, Kan., on the Kansas River, where it is crossed by the Atchison, Topeka & Santa Fe Railroad, the Topeka Edison Co., a subsidiary of the Illinois Power & Light Corp. is building a new power plant. This work was started about a year ago and among the equipment being installed are two 7500-kv.a. General Electric turbines with Worthington condensers, three 1200-hp. Babcock & Wilcox boilers which will operate at 400 lb. pressure, 250 deg. superheat, and Foster economizers. The boilers will be fired with southern Kansas coal and will be served by stokers. Furnaces will be designed, however, to burn oil and gas also.

The ultimate capacity of the plant when finished will be 75,000 kw. Power will be generated at 13,200 v. and transmitted to Topeka by a high tension line supported by steel towers and a 50-mi., double-circuit line carrying 66,000 v. will supply Atchison and vicinity. It is expected that the first unit will be put into operation about the middle of August this year.

Susquehanna River to Be Developed at Conowingo

AMONG THE most important hydroelectric projects which are now under way is that of a $50,000,000 plant at Conowingo, Md., which is being undertaken by the Susquehanna Electric Co. The final arrangements for carrying on this work have been made with the Susquehanna Power Co., Susquehanna Water Power Co. of Pennsylvania and the Philadelphia Electric Co. Application was filed with the Public Service Commission for permission to build this plant by Luther M. Willis of Baltimore, and S. A. and Frederick Williams of Belair. Temporary directors are Edward J. Curran, Joseph L. Kerr, Geo. R. Roux, M. Elwell Funk and A. Allen Woodruff.

News Notes

HELD UNDER THE joint auspices of the Baltimore Safety Council and the American Society of Safety Engineers-Engineering Section of the National Safety Council, the Baltimore Safety Conference in Baltimore, January 23, was attended by more than 200 industrial engineers and executives.

The morning program, presided over by G. W. Knapp, Jr., National Emaneling & Stamping Co., Baltimore, Md., consisted of an address on "Industrial Accidents from the Citizen's Viewpoint," by Henry S. Baker, general chairman, Baltimore Safety Council; a symposium on safety kinks, safety equipment and educational stunts by six speakers representing as many industries. R. W. Locher, an industrial surgeon of Baltimore spoke on "Safety From the Surgeon's Viewpoint," at the luncheon meeting in the Hotel Emerson. The afternoon session, presided over by Dr. M. G. Lloyd, United States Bureau of Standards, Washington, D. C., included several addresses on plant conditions, a talk on "Electrical Safety Switches," by R. L. Allewelt, General Electric Co., Philadelphia, and a discussion on exhibits of first aid materials, industrial stairs, eye protection, electric switches, etc. An evening meeting was addressed by Dr. Loyal A. Shoudy, Bethlehem Steel Corp., Bethlehem, Pa., on the subject of "The Doctor, the Foreman and the Man."

MILWAUKEE is planning a Mid-West Power Show and Mechanical Exhibition to be held in the auditorium May 18 to 21 at the time of the spring meeting of the American Society of Mechanical Engineers, the American Society of Refrigerating Engineers and the Wisconsin State meeting of the National Association of Stationary Engineers. Booths will be 8 ft. by 6 ft. and cost $50 each. Arrangements are in charge of Egbert Douglas, 217 West Water St., Milwaukee, Wis.

THE STANDARD TURBINE CORP. announces the appointment of Starkweather & Broadhurst, 79 Milk St., as its Boston representatives.

RALPH G. JOHANSEN, formerly of the Alexander Hamilton Institute and of the Hamilton College of Law, has just assumed charge of the Hays School, which conducts courses in combustion and fuel engineering.

THE AMERICAN DISTRICT STEAM CO. has recently appointed the Stanley Sales Co. as its New York City representative. This company has specialized in heating equipment and materials for underground steam and hot water lines.

H. C. VAN HOOK has been appointed chief engineer of the Kelly-Springfield Tire Co., Cumberland, Md. Mr. Van Hook was formerly with Dayton Power & Light Co. and Westinghouse Electric & Manufacturing Co. Since December, 1923, he has been operating engineer with Kelly-Springfield.

JOHN W. PARKINSON, who has been general power plant inspector for the Atchison, Topeka & Santa Fe Railroad for the past seven years, died in Los Angeles, Calif., January 23. The funeral was held in his home town in Topeka, Kan. Mr. Parkinson first started to work for the Santa Fe in 1884.

ANNOUNCEMENT has just been made by the Bailey Meter Co. of Cleveland, that it has entered into an agreement with Industrial Combustion Engineers, Ltd., London, England, whereby the latter are the sole licensees for the sale and manufacture of Bailey meter equipment in Great Britain, France, Belgium and Holland.

JOHN GAILLARD has resigned as staff engineer of the American Engineering Standards Committee to take charge of the technical standardization works of the various plants of the American Radiator Co. Mr. Gaillard's place will be taken by S. J. Koshkin, former associate editor of American Machinist, and previously on the editorial staff of the Iron Age catalog of American Exports.

THE CAREY ICE CO. of Hutchinson, Kan., is replacing its old steam plant with the latest type electrical machinery. One 30-T. York refrigerating machine driven by a 50-hp. General Electric motor and two 80-T. refrigerating machines driven by 150-hp. General Electric motors, are being installed. A 2300-v. line 2 mi. long is being built from the Carey Salt Co. to furnish the power for the ice plant. It is expected that the new plant will be in operation by the middle of March.

THE SUIT brought by Brown Instrument Co. in the Federal Court at Chicago against Republic Flow Meters Co. and certain individuals has been settled between the parties; also certain suits at law brought by Republic Flow Meters Co. and the same individuals in the same court against Richard P. Brown have been dismissed.

The officers of Republic Flow Meters Co. did not wish to be under the imputation of illegally using any of the original construction of the Brown Instrument Co. When it was called to their attention that there were pending on behalf of Brown Instrument Co. patent applications covering some of these features, the Republic Flow Meters Co. changed the construction of its indicating and recording pyrometers so as to avoid infringement either of patents or of original designs of construction of the Brown Instrument Co.

THE BOSTON OFFICE of the Dixon Crucible Co. has been moved from 49 Federal St. to 80 Federal St.—the new Chamber of Commerce Building. H. A. Nealley is district manager.

THE BOILERS in the Burlington plant of the Public Service Electric Co. of New Jersey, consisting of eight 600-hp. longitudinal and two 1418-hp. cross drum types of water-tube boilers, are being completely equipped with Tracy steam purifiers.

H. W. BROOKS, who has been Fuel Engineer for the U. S. Bureau of Mines, resigned from this post to join the Consulting Staff of the Fuller-Lehigh Co., the resignation taking effect on the 15th of February. It is the purpose of the Fuller-Lehigh Co. to make his services available to their clientele as a further contribution to the engineering service which they have rendered in the pulverized fuel field.

Catalog Notes

SARCO ENGINEERING CO., New York City, has just issued a leaflet describing the construction of the new Sarco Steam Trap No. 9, and pointing out the characteristic features of its operation.

AUTOMATIC REGULATORS for pressure, temperature, humidity, density, vacuum and speed are described in a 15-page booklet recently issued by Arca Regulators, Inc., New York, N. Y. These regulators consist essentially of an operating hydraulic cylinder and a sensitive relay control by means of which valves or other mechanisms may be operated.

HORIZONTAL water-tube boilers, cross-drum boilers and both internally fired and horizontal tubular boilers are described in Bulletin No. 52, recently published by the Freeman Manufacturing Co., Racine, Wis. The cross-drum boilers can be made in any size above 100 hp. whereas the horizontal water-tube boilers can be made up to and including 500 hp.

IN A BULLETIN entitled "Synchronous Motors for Pumping" the Electric Machinery Mfg. Co. of Minneapolis, Minn., gives considerable engineering information on the operation of this type of motor applied to pumping equipment. Several curves and tables are shown as well as many half-tone illustrations of installations in plants for pumping water for many different purposes.

"TREATISE ON GEARS" is the title of a booklet which is being distributed by the Grant Gear Works, South Boston, Mass. It treats of gear wheels and the teeth of gears in such a manner as to be of value to those who are confronted with that form of power transmission. It contains much of practical worth and was prepared with the idea in mind of eliminating complicated formulas and diagrams.

GRISCOM-RUSSELL CO. of New York has recently placed the new Vaneflo gas cooler on the market, which can be used either as an inter, after or pre cooler. It can readily be disconnected, transported and erected in new locations to meet changing conditions. Where desired, it can be furnished as a short-length twin unit to fit into small space without loss of cooling effectiveness. This cooler is described in a leaflet just issued under Form No. 208.